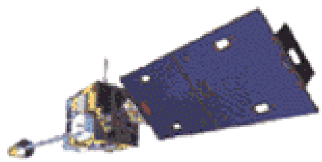
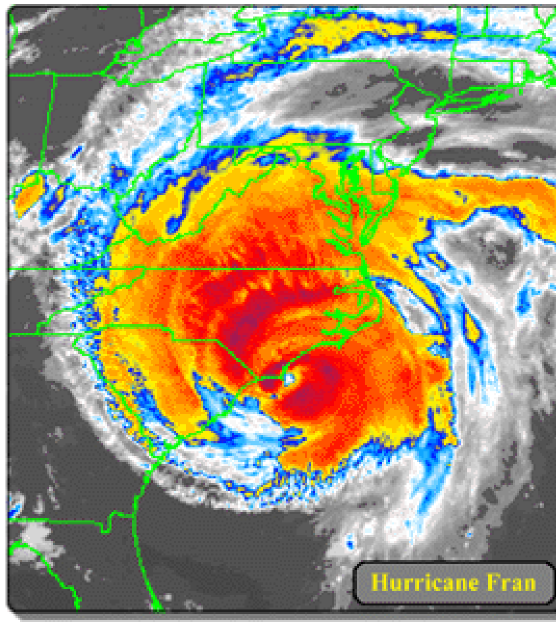
Technical Report 97-02

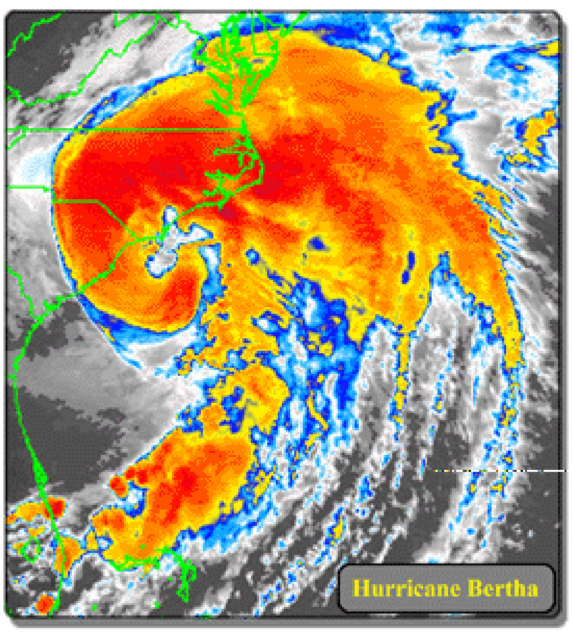
May 1997

1996 Atlantic Tropical Storms





Views From The NOAA Satellites



National Climatic Data Center

Introduction

This report, produced by the National Climatic Data Center (NCDC) in cooperation with the Tropical Prediction Center (TPC), is a preliminary summary of the 1996 Atlantic Hurricane Season. The report provides a synopsis of each named tropical storm using textual information based on the TPC Preliminary Hurricane Reports authored by Avila, et al, and remotely sensed and in-situ data received at the NCDC. The satellite imagery for each storm were taken by either the Geostationary Operational Environmental Satellite (GOES) or the Polar-orbiting Operational Environmental Satellite (POES). Additional meteorological data for Hurricanes Bertha and Fran, the two most important hurricanes affecting the U.S. mainland, are also included. The graphical products include: NEXRAD Level III Base Velocity, Base Reflectivity and Storm Total Precipitation; GOES Water Vapor Movement Winds; and total precipitation from an extensive collection of cooperative and National Weather Service stations. The statistics on deaths and damages were obtained from the TPC's Preliminary Hurricane Reports.

The infrared and visible satellite images were created from either the GOES Imager or the POES AVHRR instrument. The visible channel measures the reflectance of the objects scanned. Clouds are more reflective than surface objects which appear dark. The infrared channel measures emitted long-wave radiation from the earth and cloud tops which allows us to "see" clouds at night. Another important feature of the infrared channel is that the temperatures of cloud tops, land and ocean surfaces can be determined and color coded to enhance key features on a satellite image. Cloud tops have been colorized using a scale ranging from gray, indicating the warmest cloud tops, to maroon, indicating the coldest cloud tops (fig. 1). Land and ocean features are warmer than the clouds and were assigned a black color during the imaging process.

Ordering and Accessing Data

The NCDC maintains and provides climate and satellite data and products in a variety of formats. To order additional data or to obtain more information please contact the NCDC at 704-271-4850 or e-mail your inquiry to orders@ncdc.noaa.gov or satorder@ncdc.noaa.gov. For information about NOAA's satellite systems visit NCDC's web site at www.ncdc.noaa.gov. The Tropical Prediction Center's homepage on the Internet at www.nhc.noaa.gov offers information on past hurricanes, including hurricane tracks from 1921 to 1996, the costliest, deadliest, and most intense hurricanes of this century, the deadliest hurricanes since 1492, and the Preliminary Hurricane Reports for 1996.

Acknowledgments

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1996 Atlantic Hurricane Summary

The 1996 Hurricane season was predicted by Dr. William Gray of the Colorado State University to be above average, although not nearly as busy as it was the previous year when a near record breaking 19 named storms occurred. Nevertheless, it was a busy year for tropical storms with a total of 13 storms, 9 of which became hurricanes. Six of the hurricanes were major, reaching or exceeding a category 3 on the Saffir-Simpson Hurricane Scale. Four tropical storms, Arthur, Bertha, Fran, and Josephine, made landfall on the U.S. coast, the strongest of which was Hurricane Fran, which did an estimated $3.2 billion worth of damages in the mid-Atlantic States. Table 1 gives the name, date range, minimum pressure, maximum sustained wind speed, highest category, estimated number of deaths, and U.S. damage estimates of each storm. The four U.S. landfalling storms are highlighted.

Table 1 - 1996 Atlantic Basin Tropical Storms and Hurricanes

	Name	Dates	Minimum Pressure (millibars)	Max Wind Speed (knots)*	Saffir-Simpson Scale**	Deaths †	Damages (U.S. and territories)
1	Arthur	6/17-6/21	1004	40	n/a	0	none reported
2	Bertha	7/05-7/14	960	100	3	12	$270 million
3	Cesar	7/24-7/28	985	75	1	51	none reported
4	Dolly	8/19-8/25	989	70	1	14	none reported
5	Edouard	8/19-9/03	933	125	4	2	none reported
6	Fran	8/23-9/08	946	105	3	27	$3.2 billion#
7	Gustav	8/26-9/02	1005	40	n/a	0	none reported
8	Hortense	9/03-9/16	935	120	4	21	$127 million
9	Isidore	9/24-10/01	960	100	3	0	none reported
10	Josephine	10/04-10/08	981	60	n/a	0	$130 million
11	Kyle	10/11-10/12	1001	45	n/a	0	none reported
12	Lili	10/14-10/27	960	100	3	8	none reported
13	Marco	11/16-11/26	983	65	1	8	none reported

* Estimated maximum 1-minute average wind speed

** Saffir-Simpson Hurricane Scale. Indicates maximum strength of the storm during its lifetime. Categories: 1 (64-82 kts), 2 (83-95 kts), 3 (96-113 kts), 4 (114-135 kts), and 5 (over 135 kts)

† Estimated number of deaths from direct causes for the U.S., Caribbean, and Mexico. Does not include indirect

deaths.
See synopsis.

Following is a synopsis of each storm.

Arthur- Arthur was a weak tropical storm that moved over the Outer Banks of North Carolina on 19-20 June with sustained winds near 35 kts. The weakening storm headed out to sea and dissipated soon thereafter. Fig. 2 shows a marginal tropical storm Arthur 12 hours before it crossed over Cape Lookout, North Carolina. Winds at this time were reported at 40 kts. The early morning sun shows a well defined low level circulation with minimal deep convection. Broad convection is evident by the mass of white clouds on the northwest quadrant where locally heavy rains occurred.

Bertha- The first Cape Verde storm of the season, Bertha formed over the eastern tropical Atlantic on 5 July, unusually far to the east for so early in the season. The hurricane moved through the Leeward and Virgin Islands of the northeast Caribbean with sustained winds to 75 kts. Bertha strengthened to a category 3 hurricane on 9 July at 0600 UTC. Fig. 3 is a colorized infrared image from GOES-8 showing Bertha at about maximum intensity. Note the deep convection indicated in dark red surrounding the eye, a sign of a healthy storm. Bertha then brushed the Bahamas and lost some of its strength.

Bertha made landfall at 2000 UTC on 12 July on the coast of North Carolina, with the center crossing the coast midway between Wrightsville and Topsail Beaches. The hurricane had been gradually weakening from its top speed of 100 kts on the 9th to 70 kts on the 11th. Then, in the 12 hours just before landfall, the winds increased to 90 kts, which is the estimated maximum 1-minute wind speed at landfall. The GOES visible satellite image (fig. 4) shows the center of Bertha along the southeast North Carolina coast. The eye at this time is obscured by cirrus clouds.

The NEXRAD Level III Base Reflectivity (fig. 5) product taken by the Wilmington, North Carolina, Doppler radar shortly before landfall shows the distinctive spiral banding associated with hurricanes. The eye of the storm is just off shore east of Wilmington, North Carolina. The yellow and green bands indicate areas of moderate to heavy rain, the heaviest of which is just north of the eye.

The NEXRAD Level III Base Velocity product (fig. 6) taken at the same time as the Base Reflectivity product shows areas of horizontal wind movement with respect to the radar’s location. Positive Doppler velocities (red) indicate air moving away from the radar, whereas negative Doppler velocities (green) indicate air moving toward the radar. The grey areas indicate little or no air movement toward or away from the radar. The white spiral-like gaps next to the red and green fields indicate no data, and match well to areas where no precipitation is occurring.

Bertha, downgraded to a tropical storm, then moved northeastward along the U.S. east coast, producing 40 to 50 kt sustained winds over land from northern North Carolina to New England and 60 kt winds over nearby Atlantic waters. The primary effects in North Carolina were to the coastal counties and included storm surge flooding and beach erosion, roof damage, piers washed away, fallen trees, and damage to crops. Coastal storm surge flood heights, from Florida through New England, ranged from 1 to 4 feet, but heights to 5 feet were estimated on the North Carolina coast from Cape Fear to Cape Lookout. A storm surge of 6 feet or a little higher was indicated near Swansboro, North Carolina.

Bertha dumped copious amounts of rain along the Atlantic eastern seaboard from the South Carolina/North Carolina border northward to the Canadian Maritimes. As much as 14 inches of rain was recorded near Hofmann Forest, North Carolina. Fig.7 shows the areal extent of heavy rainfall and table 2 lists locations reporting 5 inches or more of precipitation. The source of the data came from the NCDC TD3200 Summary of the Day database comprised of over 5000 National Weather Service stations and NWS cooperative weather stations.

Bertha produced approximately $135 million dollars in insured property losses, primarily along coastal North Carolina. A conservative ratio between total damage and insured property damage, based on past land falling hurricanes, is 2 to 1. Therefore, the total U.S. damage estimate is 2 times $135 million or $270 million dollars. No figures are available from the Caribbean. Eight casualties were reported by Reuters News Agency.

Cesar- Cesar developed in the southeastern Caribbean and moved mainly westward. Cesar passed over Curacao as a tropical storm. When Cesar moved over the open waters of the southwestern Caribbean Sea, it began to strengthen and became a hurricane on 27 July at 1200 UTC. Fig. 8 shows Hurricane Cesar getting more organized with large convective areas, indicated in red, rotating around an open center. Later, Cesar hit Nicaragua with 70 kt winds and maintained tropical storm strength while passing over Central America, causing considerable death and damage.

Dolly- Born over the northwest Caribbean, Dolly became a category 1 hurricane on 22 July and soon made landfall on the east coast of the Yucatan Peninsula (Fig. 9). After weakening to a tropical storm over the Yucatan, the westward moving Dolly regenerated into a 70 kt hurricane over the Bay of Campeche and made its final landfall in Mexico just south of Tampico.

Edouard- The second Cape Verde storm of the season, Edouard, was the most intense hurricane of the season. Far out in the tropical Atlantic Ocean, its winds reached 125 kts making it a solid category 4 hurricane. For over a week, from 24 August to 1 September, Edouard maintained sustained winds of 100 kts or higher. Fig 10 shows a GOES-8 infrared image taken on 25 August at 1515 UTC, illustrating a very impressive, well organized hurricane. Fortunately, Edouard was several hundred miles away from any land mass, and at the time, a deep-layer cyclone to the east of Bermuda had caused Edouard's movement to change from westward to west-northwestward.

Edouard moved relentlessly towards the west-northwest, at around 12 kts, until the 29th of August. This track kept the hurricane well to the northeast and north of the islands of the northeastern Caribbean Sea. On the 29th, a mid-tropospheric trough became established near the U.S. east coast, creating a more northward steering component for Edouard. Slowing its forward speed slightly, the hurricane turned northwestward, and then northward, while gradually weakening. The cyclone passed about midway between Cape Hatteras and Bermuda on 1 September, and then started moving slightly east of north. Late on the 1st, the hurricane wobbled toward the north, in the general direction of southeastern New England as depicted by the POES visible image (fig. 11) taken at 1826 UTC that same day. However, early on the 2nd, Edouard veered sharply toward the northeast, and the center of the hurricane passed about 75 nautical miles southeast of Nantucket Island around 0900 UTC, the closest point of approach to the United States. Maximum sustained winds near the center of the storm had diminished to near 70 kts by that time, however, southeastern New England was brushed with hurricane force wind gusts.

Fran- Fran was the most destructive hurricane of the season. It developed near the Cape Verde Islands and followed a long track over the tropical Atlantic like Edouard. Fran strengthened to a category 3 hurricane by the time it was northeast of the central Bahamas on 4 September. A very impressive POES visible image (fig. 12) captured Fran nearly at maximum strength. Note the well-defined eye surrounded by dense white cloud tops, indicative of tremendous upward motion of air.

The powerful tropical cyclone began to be influenced by a cyclonic circulation centered over Tennessee depicted in fig.14. The GOES water vapor image taken on 4 September at 18:15 UTC is overlaid with a two-level water vapor wind vector plot. Fran was steered by the resulting flow around the upper level low and the western extension of the subtropical ridge over the northwest Atlantic. The hurricane gradually turned toward the northwest and then north-northwest and increased in forward speed. The minimum central pressure dropped to 946 mb and maximum sustained surface winds reached 105 kts, Fran’s peak intensity, near 0000 UTC on 5 September. At that time the hurricane was centered about 250 nautical miles east of the Florida east coast, just about 24 hours away from landfall on the North Carolina coast.

The center moved over the Cape Fear area around 0030 UTC 6 September with 100 kt winds resulting in significant storm surge flooding, as well as widespread wind damage over North Carolina and Virginia. The GOES colorized infrared image (fig. 13) shows a very impressive hurricane about to make landfall. The dark red areas indicate the coldest cloud tops, usually associated with strong thunderstorms. Note the nearly enclosed eye with its eastern and northern eyewall (deep red band) moving over land. An automated coastal marine station at Frying Pan Shoals, just offshore coastal North Carolina, reported a 108 kt peak wind gust, while Atlantic Beach and Greenville both reported 87 kt gusts. Storm surge on the North Carolina coast destroyed or seriously damaged numerous beachfront houses. Still water mark elevations on the inside of buildings, indicative of storm surge, ranged from 8 to 12 feet.

The NEXRAD Base Reflectivity (fig.15) and Base Velocity Level III (fig. 16) products graphically show the echoes and wind fields, respectively, taken by the NEXRAD Doppler radar station in Wilmington, North Carolina. These two products were created just minutes before landfall and about the same time as the GOES satellite image. The Base Reflectivity product clearly locates the large center of the storm with its northern eye wall moving inland. The Base Velocity product shows that the radius of hurricane force winds, much larger than Bertha's, likely extended over much of the North Carolina coastal areas of Brunswick, New Hanover, and Pender counties.

Widespread wind damage to trees and roofs, as well as downed power lines, occurred as Fran moved inland over North Carolina and Virginia. Extensive flooding was responsible for additional damage in the Carolinas, Virginia, West Virginia, Maryland, Ohio, and Pennsylvania. Fig.17 shows the area affected by one inch and greater rainfall based on the data from the NCDC TD3200 Summary of the Day database, which is comprised of over 5000 National Weather Service stations and NWS cooperative weather stations. The main band of heaviest rainfall, averaging 6 inches or more, closely followed the center path of the storm. Table 3 lists the individual stations, locations, and total rainfall equal to or greater than five inches of rain. A National Weather Service cooperative weather station in Luray, Virginia, near the Shenandoah National Park, received the greatest officially reported amount with 14.17 inches. Other tremendous amounts of rain, enhanced by the orographic effects of the central Appalachian Mountains were reported. According to Storm Data reports by the National Weather Service, there were measurements of up to 15.61 inches of rain on the highest peaks of the Shenandoah National Park where Fran passed just to the south. The Wilmington Doppler radar Storm Total Precipitation product (fig. 18) is included for comparison to the ground truth data. In this case, the radar data and station measurements are in fairly good agreement for southeastern North Carolina, well south of Raleigh, North Carolina, when the radar was still in operation. The radar's last storm total was collected at 4:29 UTC on 6 September before the radar stopped recording data.

The National Weather Service reported that Hurricane Fran was directly responsible for 27 deaths. However, the North Carolina Emergency Management Agency reported 24 storm-related deaths for the state.

The Property Claim Services Division of the American Insurance Services Group reports that Fran caused an estimated $1.6 billion dollars in insured property damage to the United States. This estimate includes $1.275 billion in North Carolina, $20 million in South Carolina, $175 million in Virginia, $50 million in Maryland, $20 million in West Virginia, $40 million in Pennsylvania, and $20 million in Ohio. A conservative estimate of total property damage in the U.S. is $3.2 billion. However, estimates from the state emergency management agencies indicate overall damages exceeded $5 billion with $5.2 billion estimated by the North Carolina Emergency Management Agency in North Carolina alone.

Gustav- A marginal tropical storm, Gustav developed over the eastern Atlantic and remained far out at sea. Fig. 19 shows Gustav at the center of the image at maximum intensity with 40 kt sustained winds.

Hortense- Hortense became the second category 4 hurricane and the fourth category 3 hurricane on the Saffir-Simpson Hurricane Scale of the season. It formed over the tropical Atlantic and crossed the southwestern tip of Puerto Rico with 70 kt winds and torrential rains causing flash floods and mud slides. Hortense then spread hurricane conditions over the eastern Dominican Republic and the Turks and Caicos Islands. It turned northward well to the east of the U.S. East Coast while becoming the second strongest hurricane of the year with 120 kt winds. The two GOES images (figs.20 & 21) provide a close-up visible view and a broad infrared view, respectively, of Hurricane Hortense with near maximum sustained winds of 115 kts on 12 September at 1845 UTC. Both images portray a markedly well-defined eye completely surrounded by dense cirrus clouds produced by strong updrafts within thunderstorms. A hurricane hunter plane reported a minimum pressure of 935 mb, a closed eyewall of 11 nautical miles in diameter, and an excellent stadium effect (outward slope of the convective clouds in the eyewall) at 2323 UTC. Hortense finally crossed Nova Scotia as a weakening hurricane on 15 September.

Isidore- The last hurricane of 1996 to form over the eastern tropical Atlantic, Isidore stayed harmlessly out over the open waters of the east-central Atlantic. Isidore briefly reached a category 3 on 28 September. Fig. 22 shows Hurricane Isidore just before turning northward on 27 September.

Josephine- Forming over the southwest Gulf of Mexico, Josephine became a tropical storm on 6 October at 1800 UTC when banding features, characteristic of tropical cyclones, began to get organized. A strong mid-latitude, deep-layer trough began to dominate the eastern half of the United States, and on the 6th and 7th the tropical storm was steered eastward to northeastward, at an increasing forward speed on the southeast flank of this trough. Early on the 7th, Josephine strengthened significantly and was nearing hurricane intensity. This trend proved to be temporary, however, as vertical shear began to increase over the northeast Gulf. Josephine's cloud structure became more asymmetric, with nearly all of the deep convection northeast of the center (fig. 23). The storm's intensity topped at 60 kts and maintained that intensity as it moved over Apalachee Bay, Florida, on the evening of the 7th. Josephine then crossed the coast in a relatively uninhabited region of north Florida, in Taylor County, at about 0330 UTC on the 8th of October. Josephine quickly became extratropical after crossing the coast. It then raced northward along the U.S. eastern seaboard reaching the Canadian Maritimes before turning out to sea.

Kyle- A short-lived tropical storm, Kyle formed over the northwest Caribbean Sea on 11 October. It weakened to a tropical depression and moved inland near the border of Honduras and Guatemala as a tropical depression on 12 October without making a significant impact. Fig. 24 shows a somewhat disorganized tropical storm Kyle east of Belize on 11 October at 2115 UTC. Maximum sustained surface winds of 45 kts were estimated.

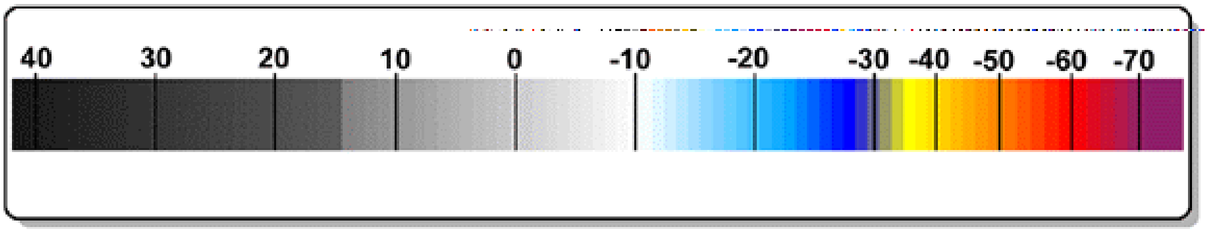
Lili- Lili was the sixth and last major hurricane of the season. It became a tropical storm early on the 16th of October when the center was close to Swan Island. With a well-established outflow over the circulation, Lili strengthened to a hurricane on the 17th. Fig. 25 shows Hurricane Lili with a well-defined circulation over the western Caribbean. Lili moved over the Isle of Youth and the main island of Cuba on the 17th and 18th with 85 kt sustained winds. At least one location in Cuba reported over 20 inches of rain. The hurricane exited the north central coast of Cuba and headed east-northeastward toward the Bahamas. The core of the hurricane moved over the Bahamian islands of Great Exuma, Long Island, and San Salvador. Maximum sustained winds reached 100 kts just after Lili moved through the Bahamas. Lili lost its tropical characteristics over the North Atlantic on the 27th, and then later moved over the British Isles as a vigorous extratropical storm.

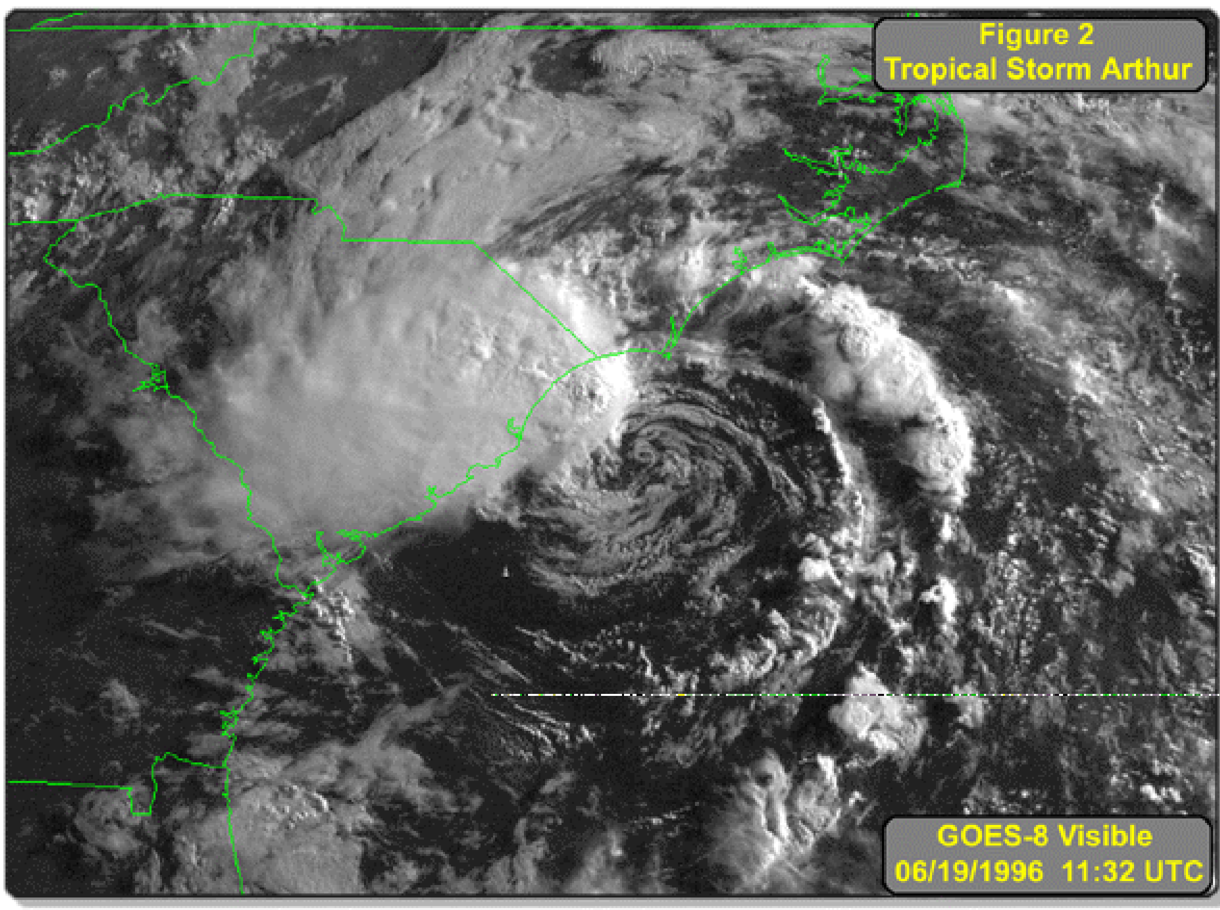
Marco- A broad low pressure area that persisted over the western Caribbean region for several days in mid-November finally formed into the last hurricane of the season. Marco briefly reached hurricane status at 0600 UTC 20 November with maximum winds of 65 kts and a minimum pressure of 983mb. Fig. 26 is a colorized infrared GOES image showing a band of convection across the Caribbean. Marco is in the center of the image. The dark red indicates heavy thunderstorms with some anti-cyclonic outflow. However, as with many marginal hurricanes, no eye is apparent. After weakening to a tropical depression, Marco regenerated back to a tropical storm before finally dissipating east of Yucatan on the 26th.

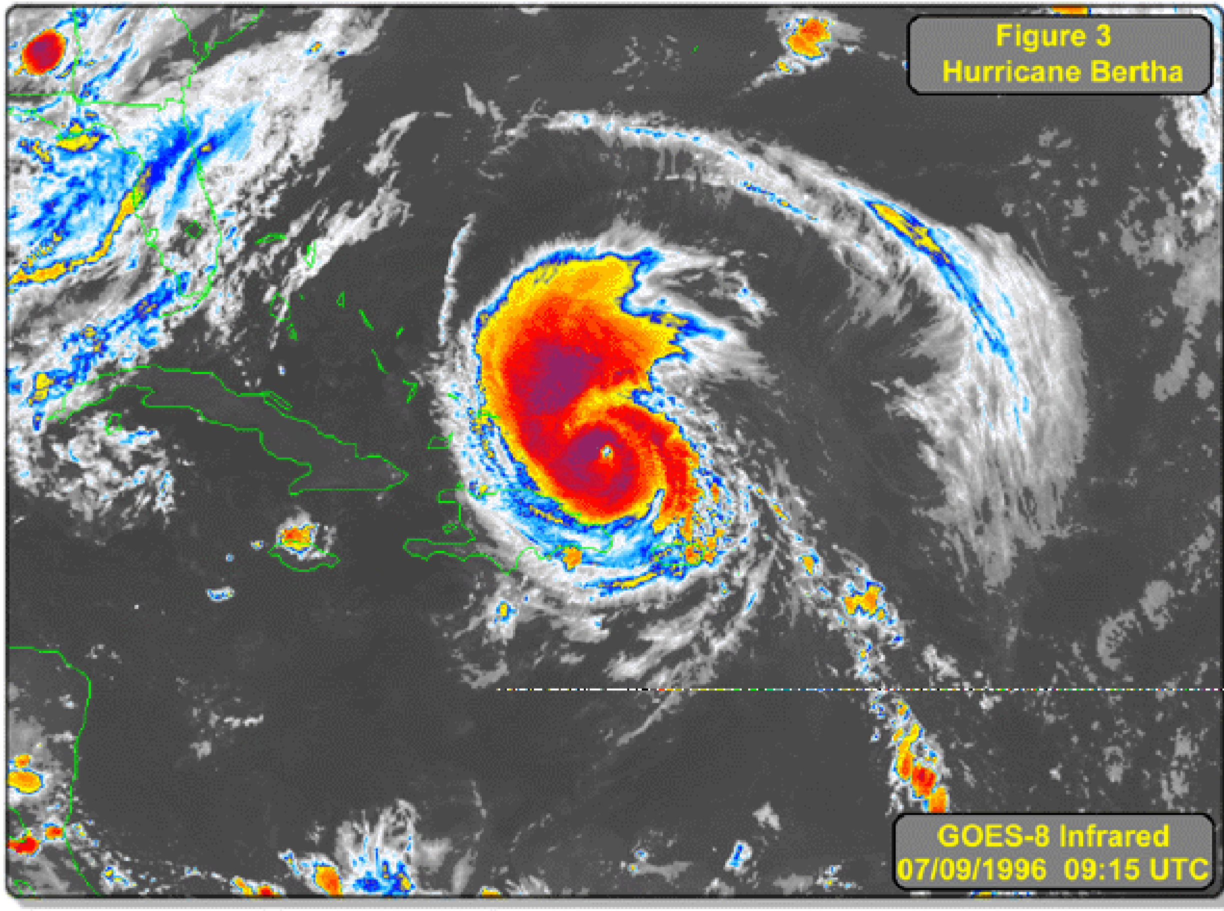
As with the hurricane season of 1995, a series of simultaneously occurring tropical storms paraded across the Atlantic. The 1996 Parade of Storms (figs. 27 & 28) featured Hurricanes Edouard and Fran, and Tropical Storm Gustav, as shown on the visible and colorized infrared images taken by GOES-8 on 29 August 1996. The National Hurricane Center's 1996 Hurricane Track Chart is provided in fig. 29.

List of Figures

Figure 1. Color vs. Temperature (C) Scale For GOES Infrared Imagery



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Hurricane Bertha
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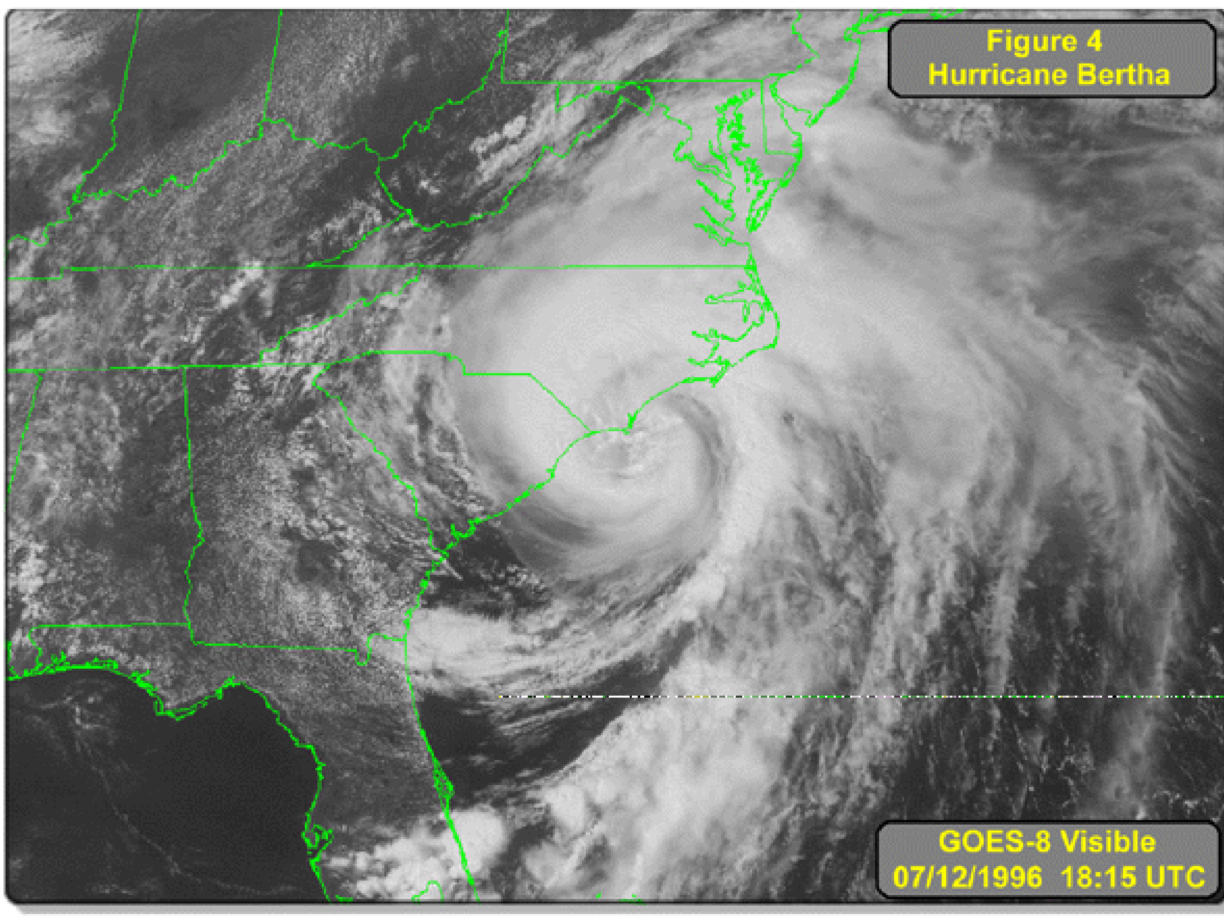
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GOES-8 Visible
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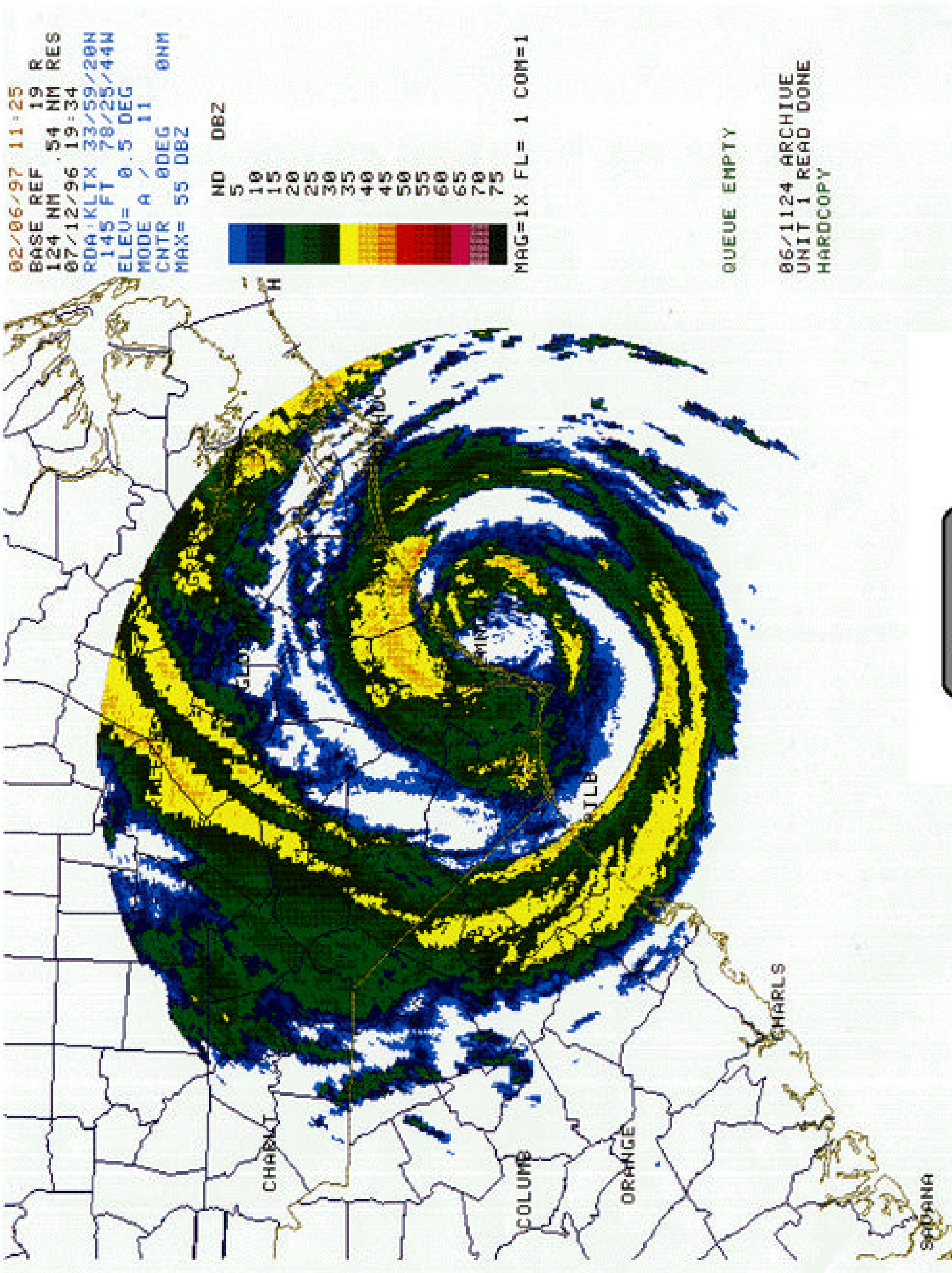
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ELEV= 0.5 DEG
MODE A / 11
CNTR 0DEG 0NM
MAX= 55 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
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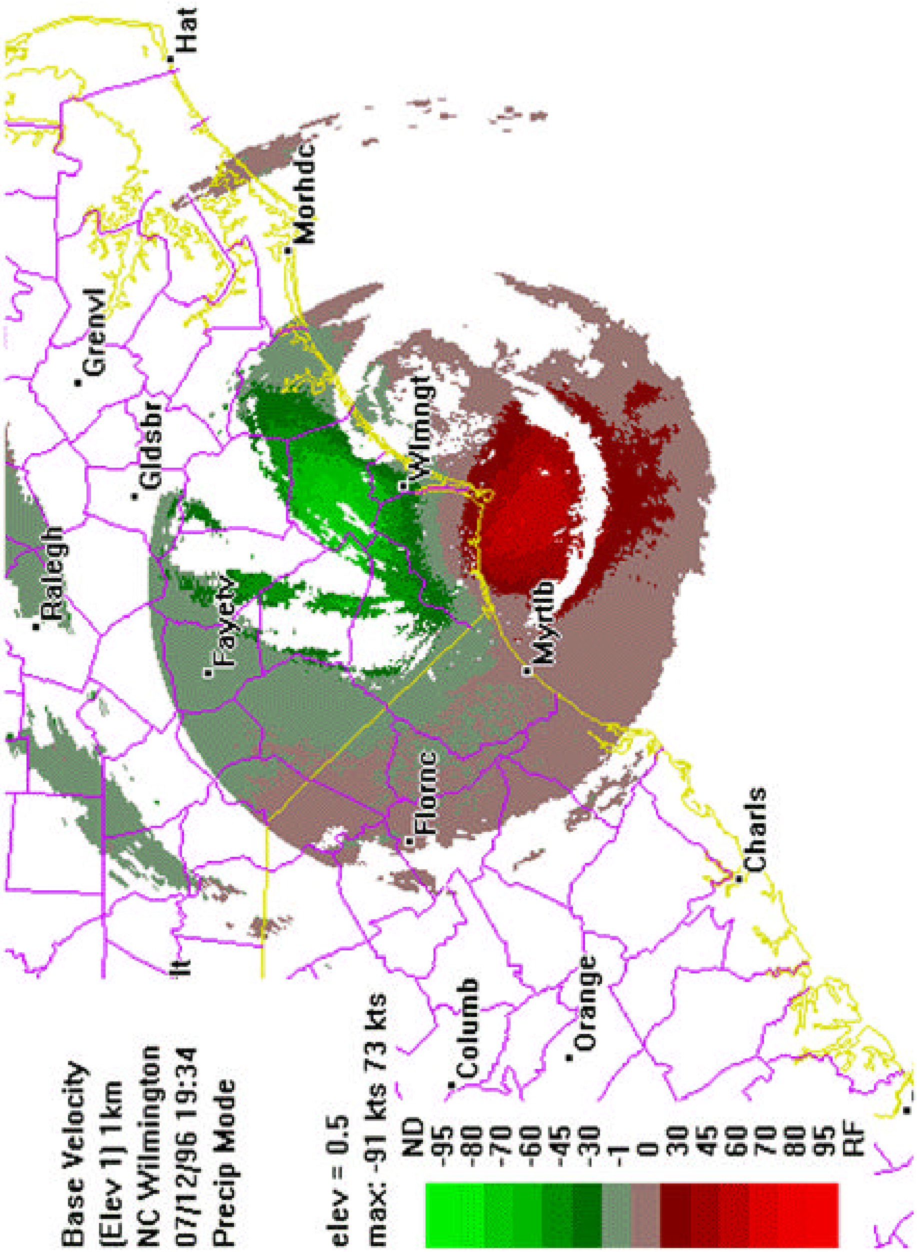
CHARLT
COLUMB
ORANGE
CHARLS
ILM

Figure 5



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-70
-60
-45
-30
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0
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45
60
70
80
95
RF
Hat
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Fayetv
Myrtlb
Flornc
Charls
Columb
Orange

Figure 6

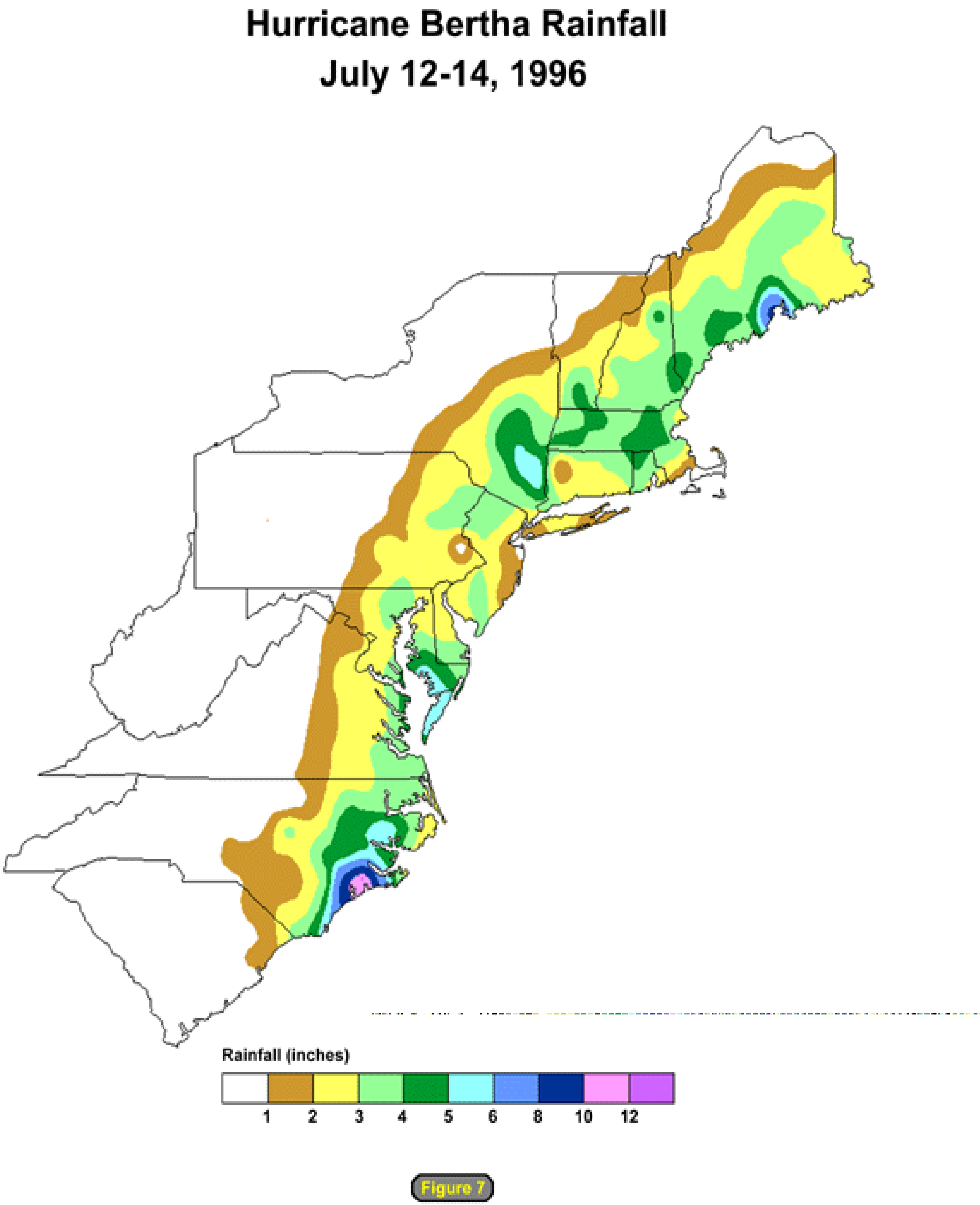
Hurricane Bertha Rainfall
July 12-14, 1996
Rainfall (inches)
1 2 3 4 5 6 8 10 12
Figure 7

Table 2

Bertha Rainfall (5 in. or greater), July 12-14,1996

St	Station	Lat. dg	Lat. mn	Lon. dg	Lon. mn	Rain (in.)
NC	Hofmann Forest	34	50	77	18	14.00
ME	Belfast	44	24	69	0	10.40
NY	Stormville	41	32	73	44	8.00
NC	Belhaven	35	33	76	38	7.60
NJ	Estell Manor	39	25	74	38	6.59
VA	Painter 2 W	37	35	75	49	6.55
MD	Vienna	38	29	75	50	5.80
NY	Rosendale 2 E	41	51	74	3	5.80
MA	Colrain	42	40	72	42	5.75
NC	Snow Hill	35	32	77	41	5.72
NC	Washington 1 E	35	32	77	1	5.55
MA	New Salem	42	27	72	20	5.50
NC	Wilmington-New Hanover	34	16	77	54	5.37
MD	Princess Anne	38	13	75	41	5.35
NC	Wilmington 7 N	34	19	77	55	5.30
NH	Mount Washington	44	16	71	18	5.29
NY	East Jewett	42	14	74	8	5.26
NY	Poughkeepsie	41	38	73	55	5.26
NY	Slide Mountain	42	1	74	25	5.26
ME	West Rockport 1 NNW	44	12	69	9	5.25
NY	Mohonk Lake	41	46	74	9	5.19
PA	New Park	39	44	76	30	5.18
NC	Southport	34	0	78	1	5.10
NJ	Charlotteburg Reservoir	41	2	74	26	5.10
NY	Cairo 4 NW	42	19	74	2	5.10
NH	Rochester	43	18	70	59	5.09
MA	Groveland	42	45	71	3	5.06

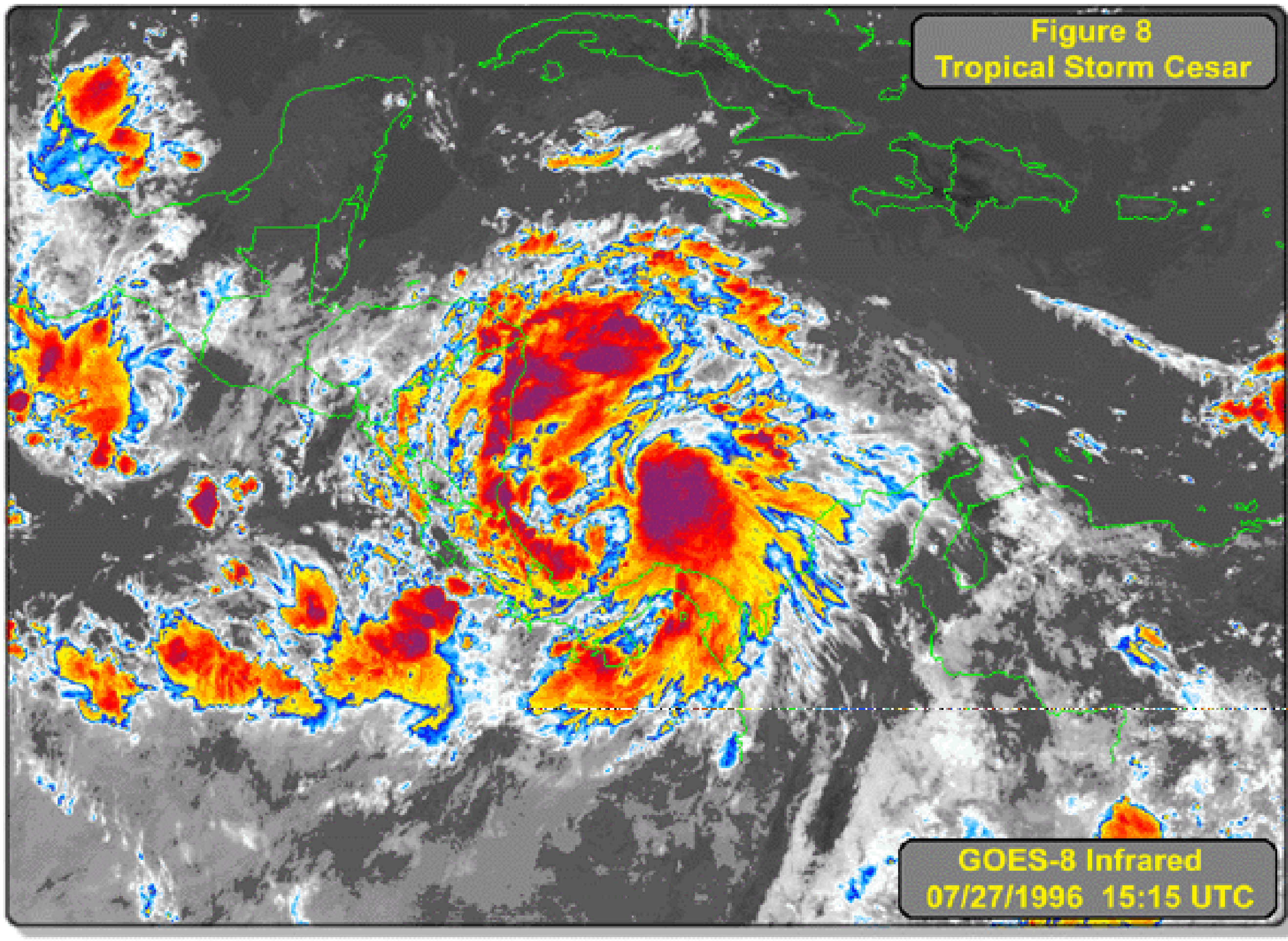
Figure 8
Tropical Storm Cesar
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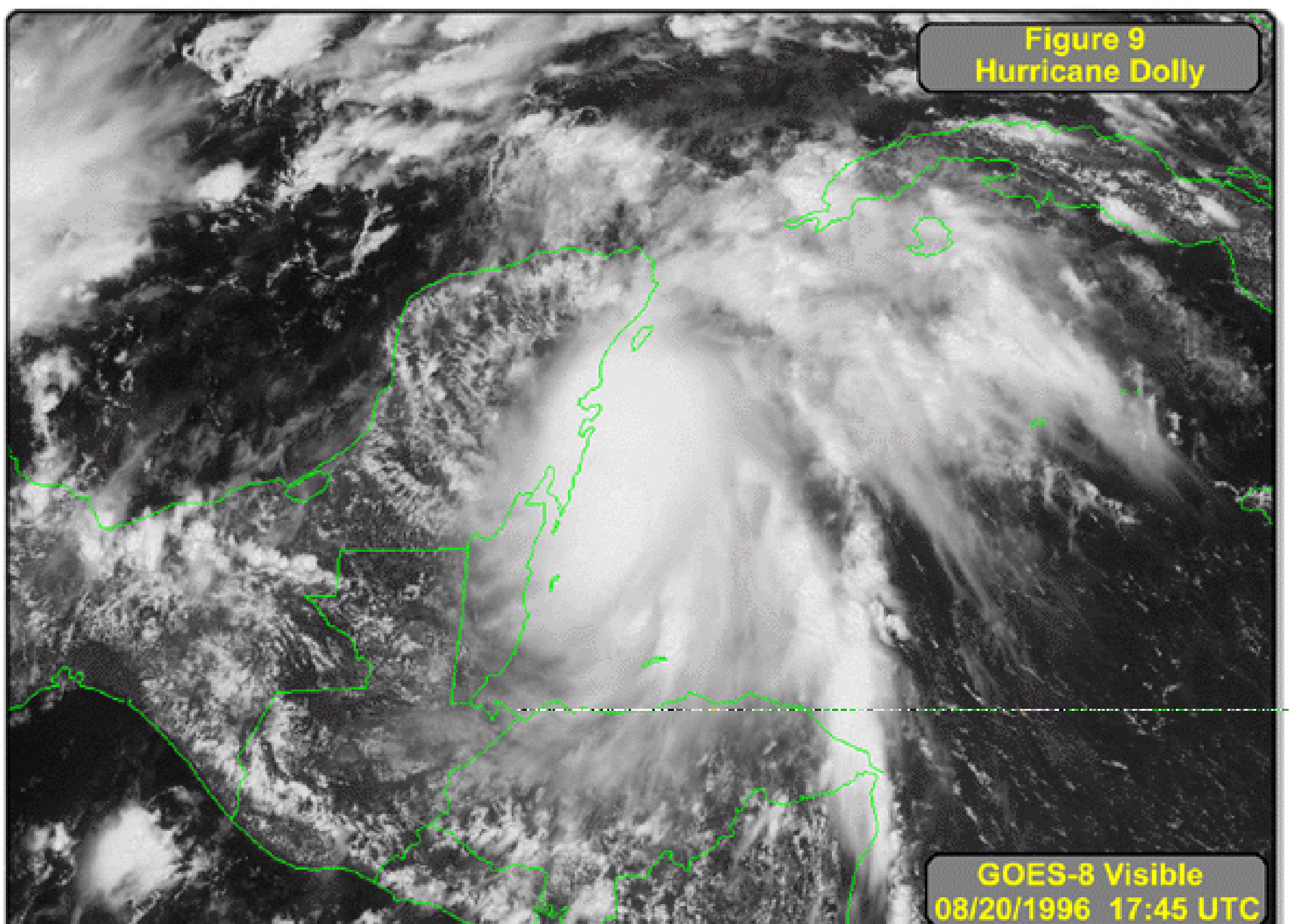
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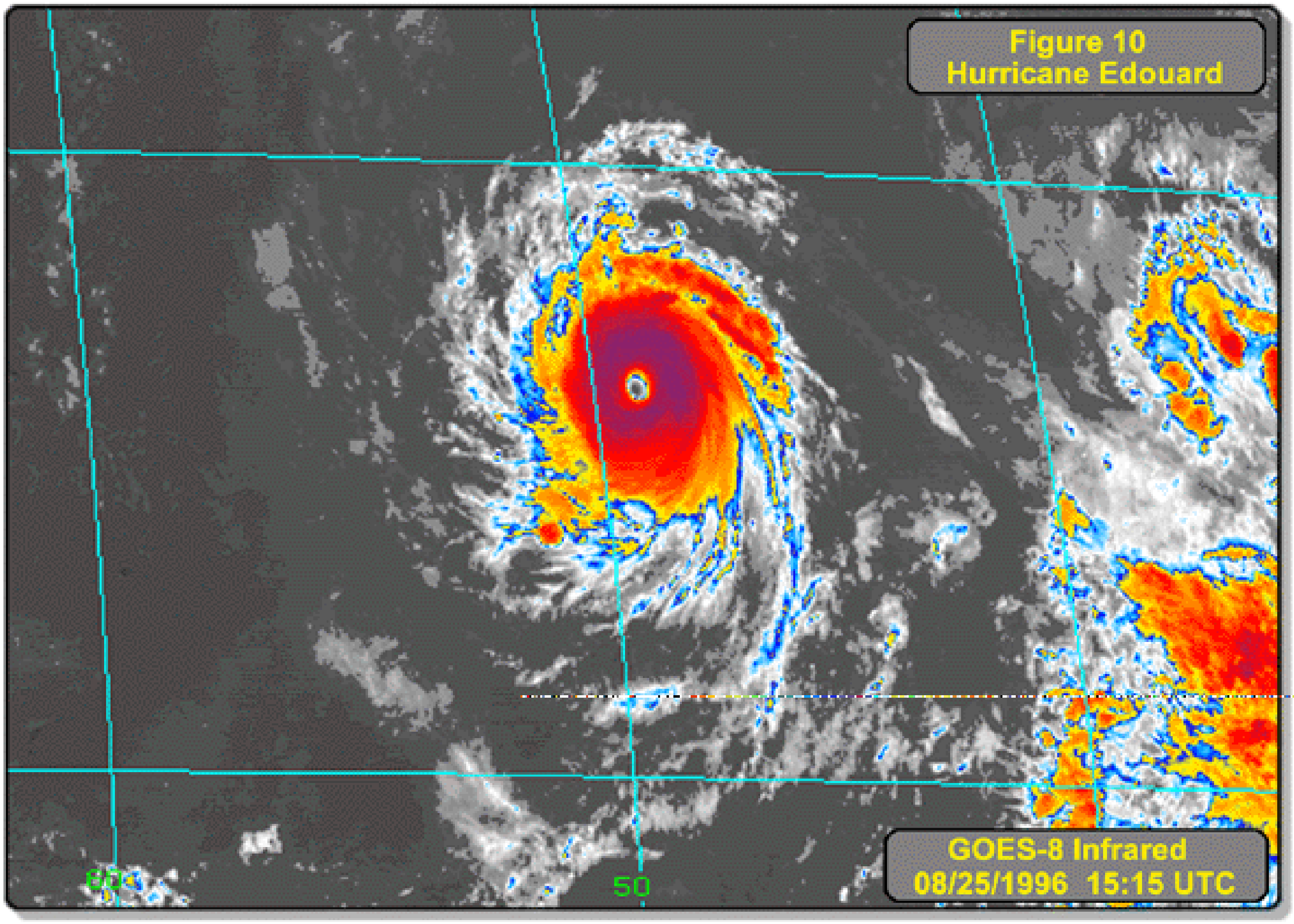
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Hurricane Edouard
GOES-8 Infrared
08/25/1996 15:15 UTC
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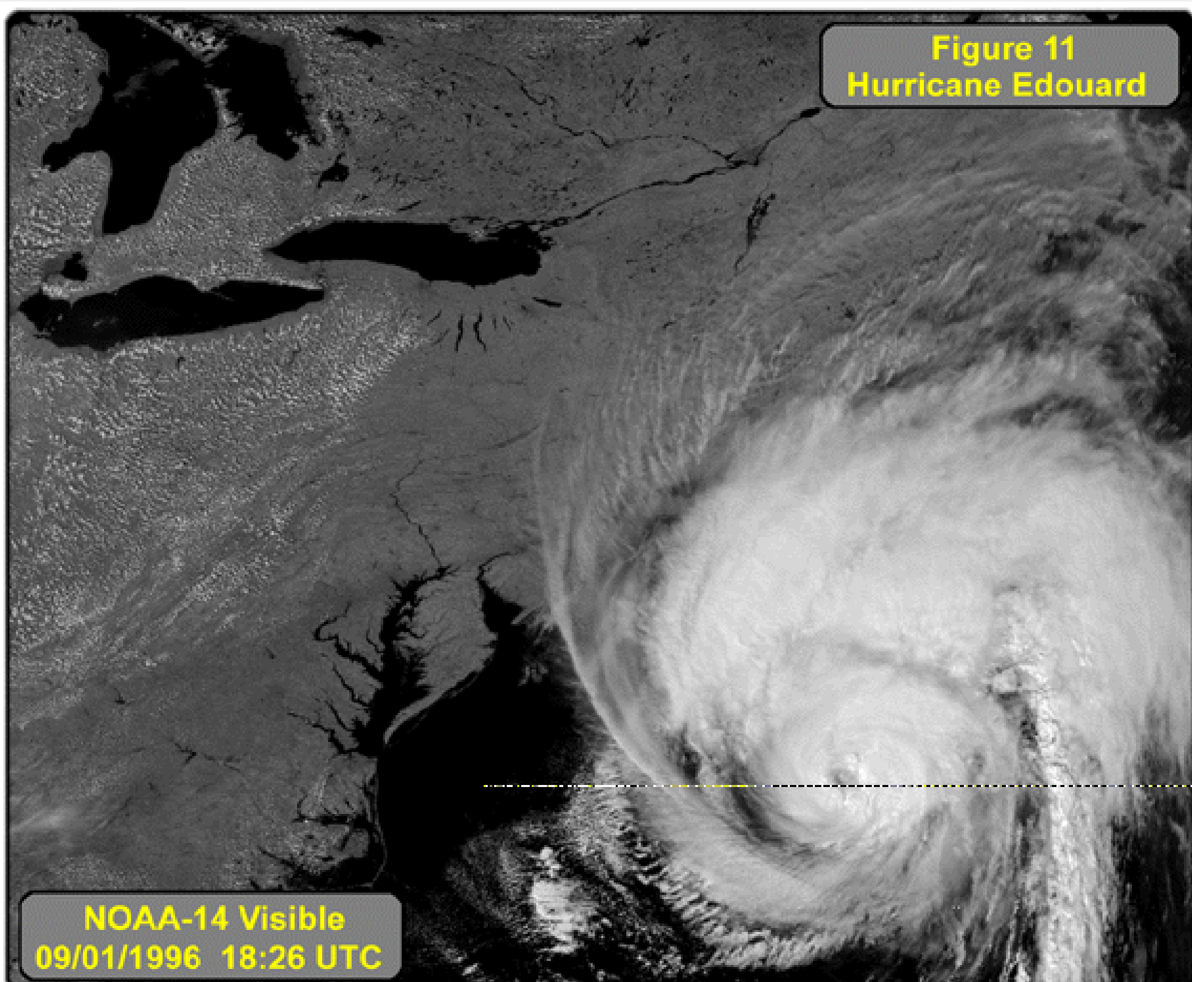
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Hurricane Edouard
NOAA-14 Visible
09/01/1996 18:26 UTC

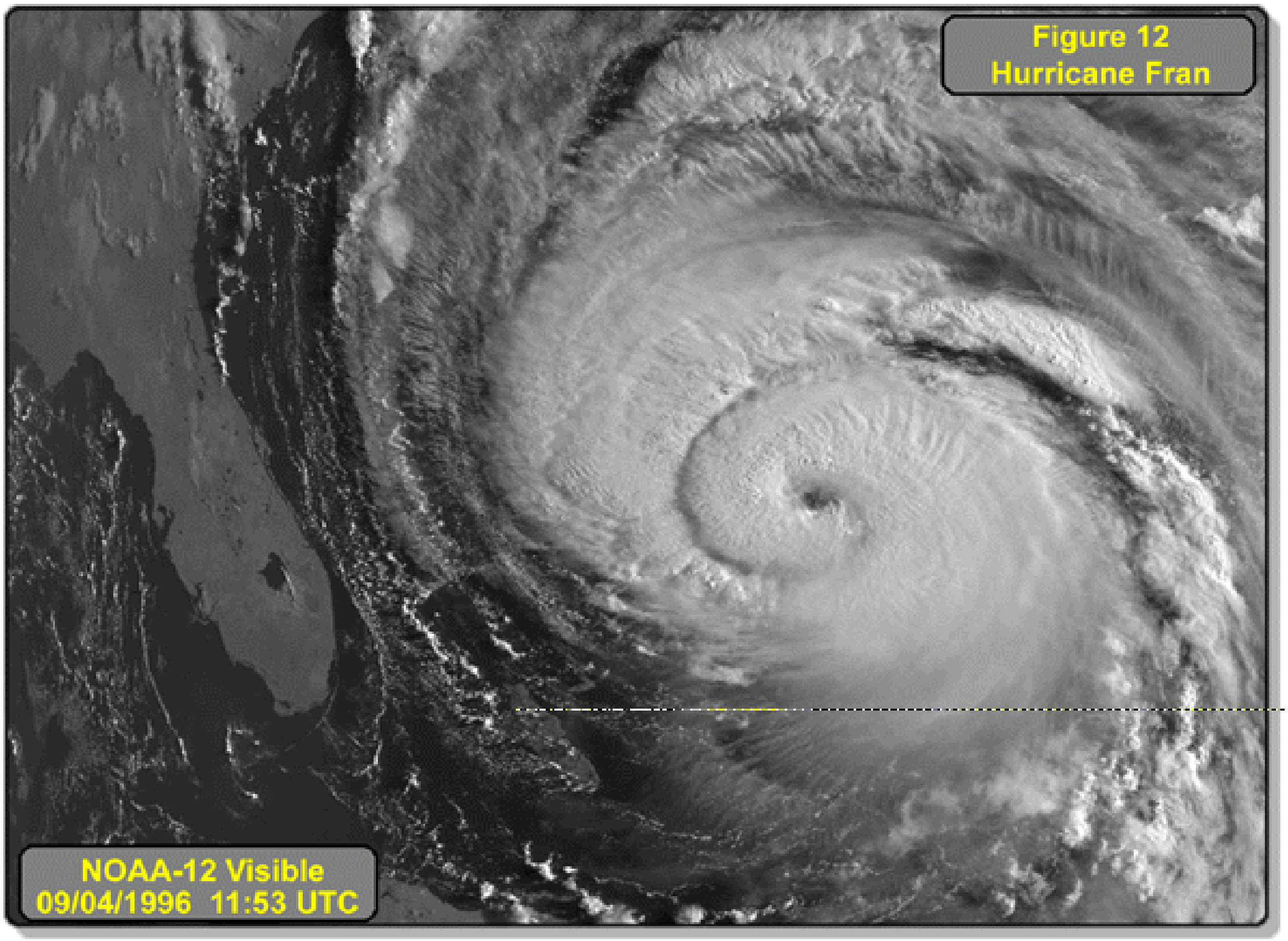


Figure 12
Hurricane Fran
NOAA-12 Visible
09/04/1996 11:53 UTC

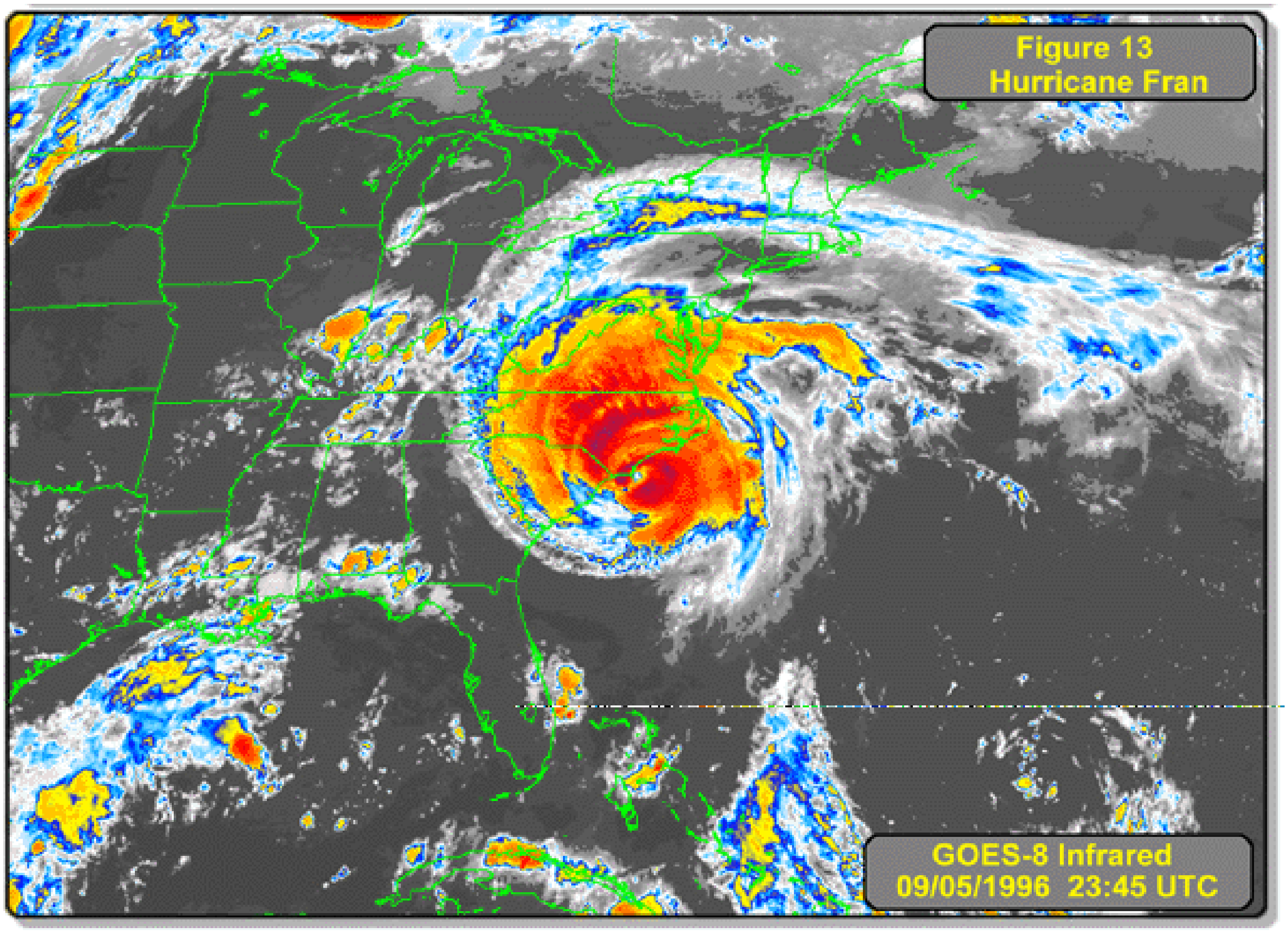
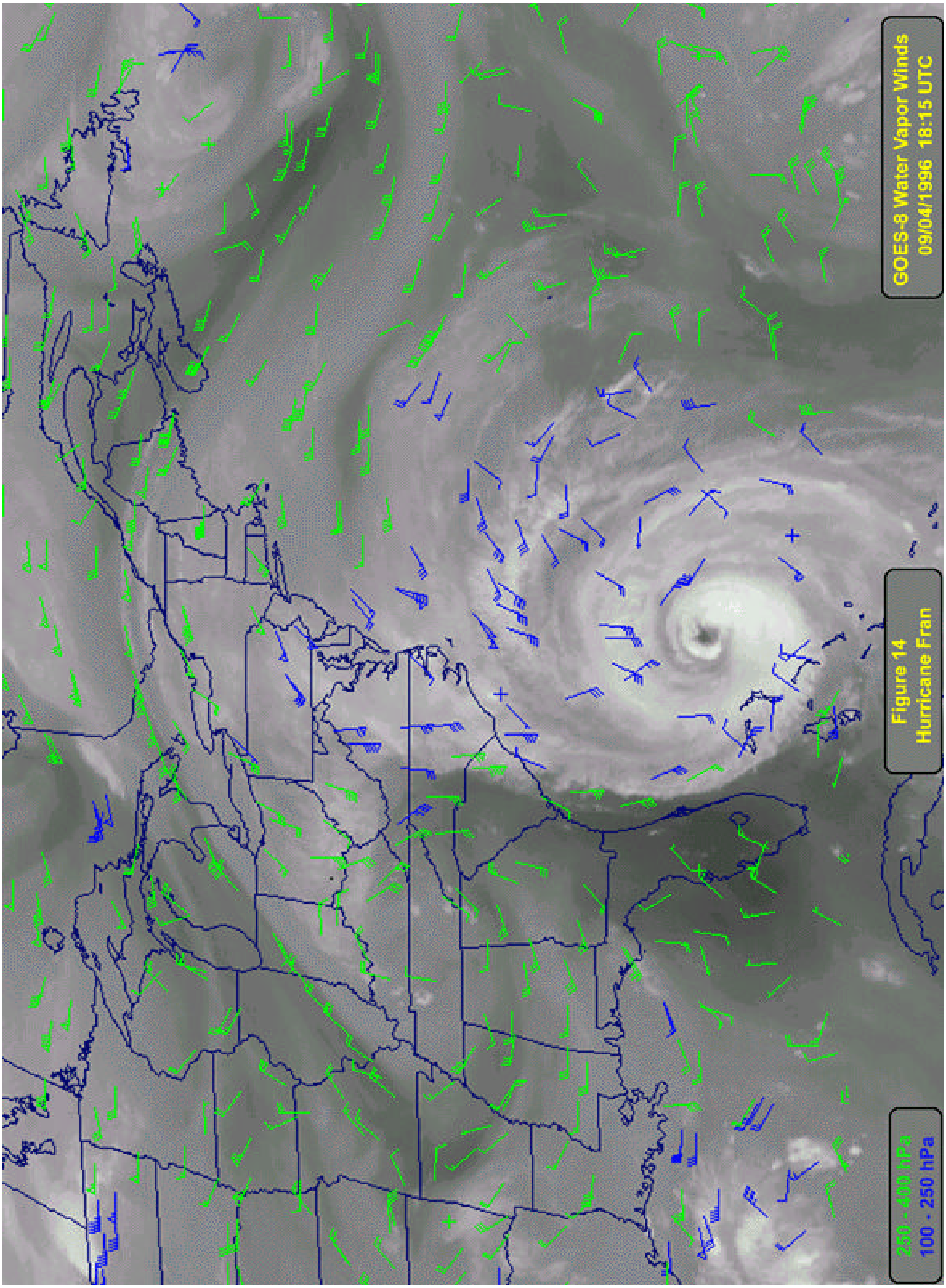


Figure 13
Hurricane Fran
GOES-8 Infrared
09/05/1996 23:45 UTC


GOES-8 Water Vapor Winds
09/04/1996 18:15 UTC
Figure 14
Hurricane Fran
250 - 400 hPa
100 - 250 hPa

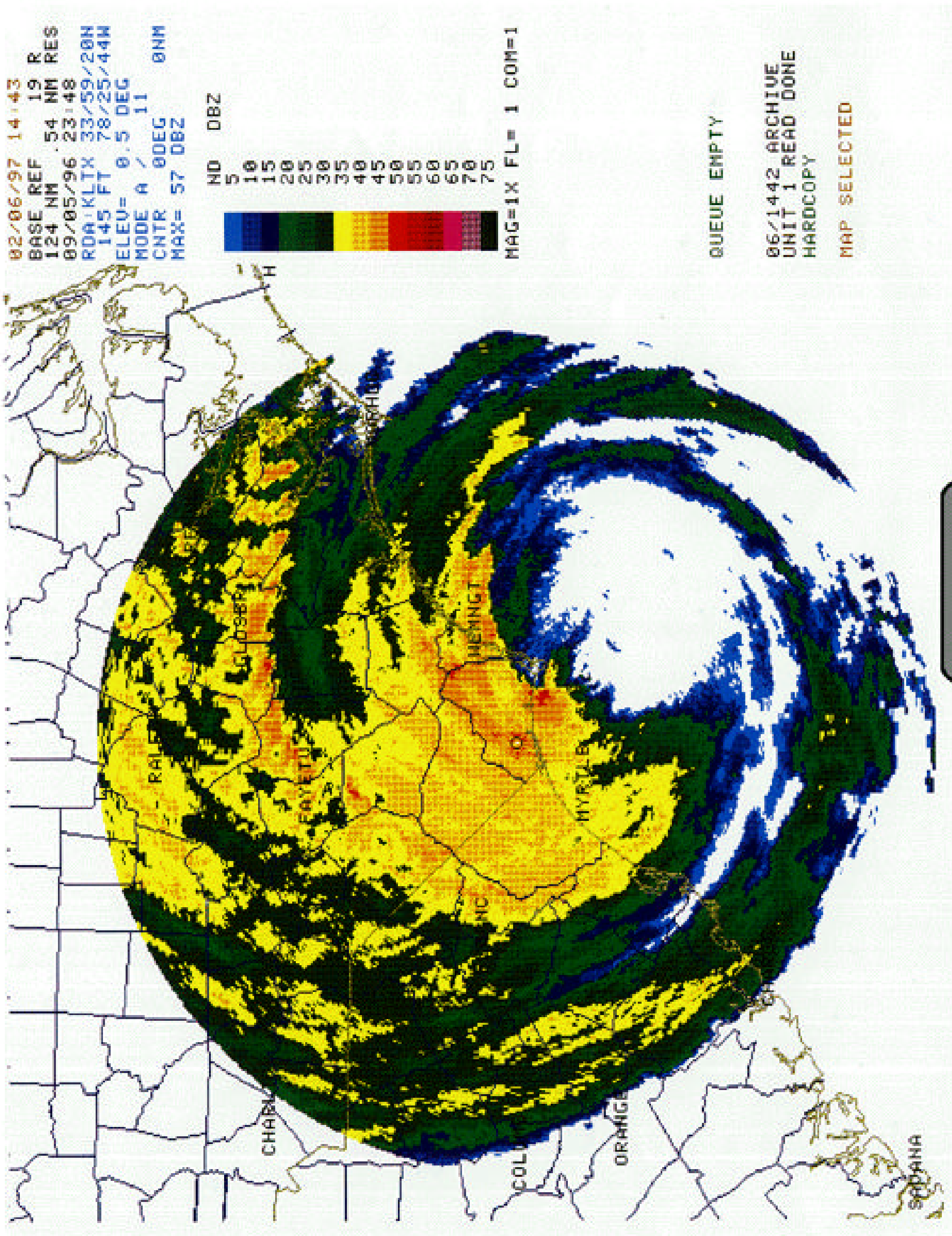

02/06/97 14:43
BASE REF 19 R
124 NM .54 NM RES
09/05/96 23:48
RDA:KLTX 33/59/20N
145 FT 78/25/44W
ELEV= 0.5 DEG
MODE A / 11
CNTR 0DEG 0NM
MAX= 57 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=1X FL= 1 COM=1
QUEUE EMPTY
06/1442 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
MAP SELECTED
RAL
FAYETT
GLDSBR
WLMNGT
MYRTLB
CHARL
COL
ORANGE

Figure 15

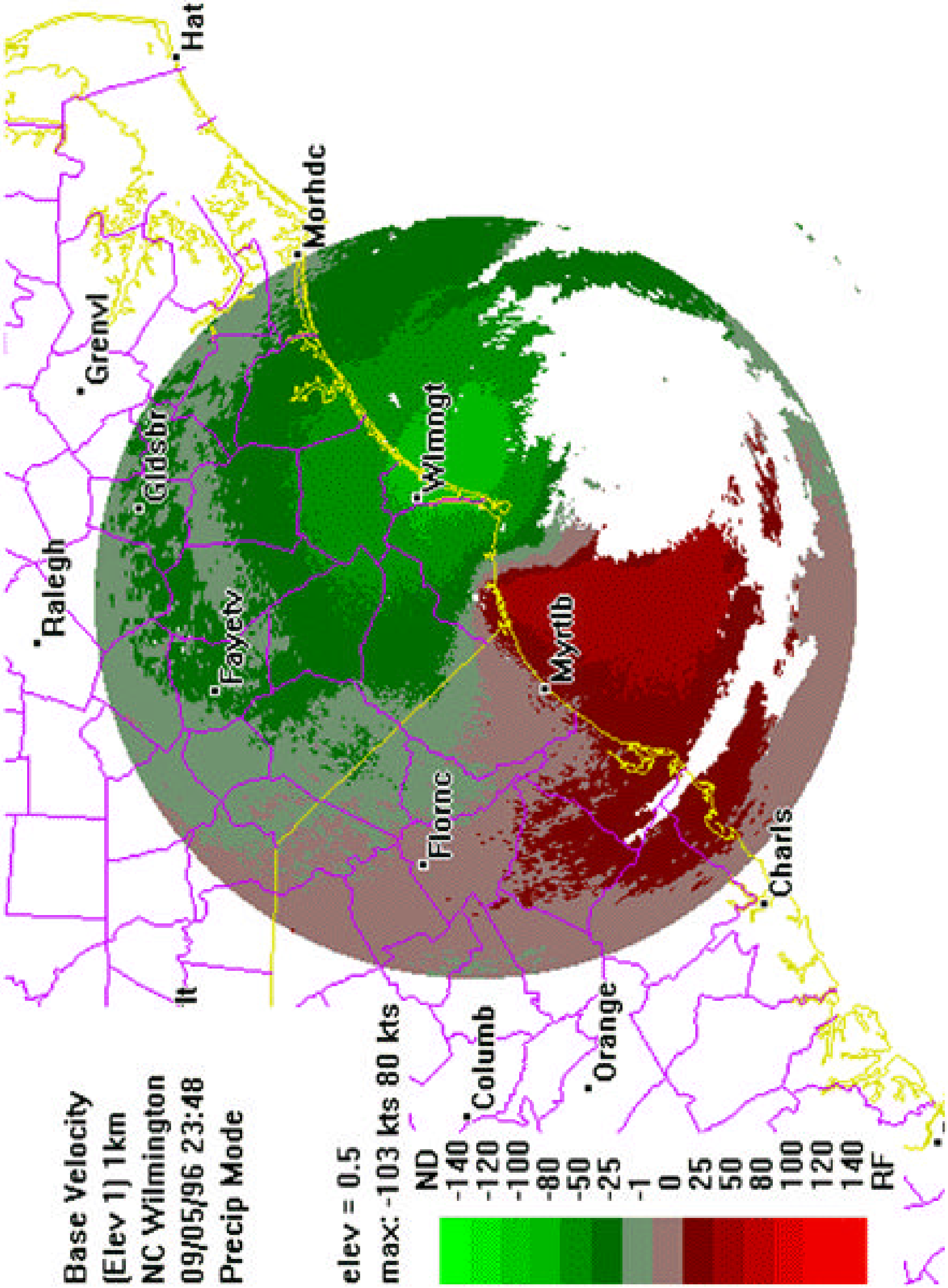

Base Velocity
(Elev 1) 1km
NC Wilmington
09/05/96 23:48
Precip Mode
elev = 0.5
max: -103 kts 80 kts
ND
-140
-120
-100
-80
-50
-25
-1
0
25
50
80
100
120
140
RF
Hat
Morhdc
Grenvl
Ralegh
Gldsbr
Wlmngt
Fayetv
Myrtlb
Flornc
Charls
Columb
Orange

Figure 16

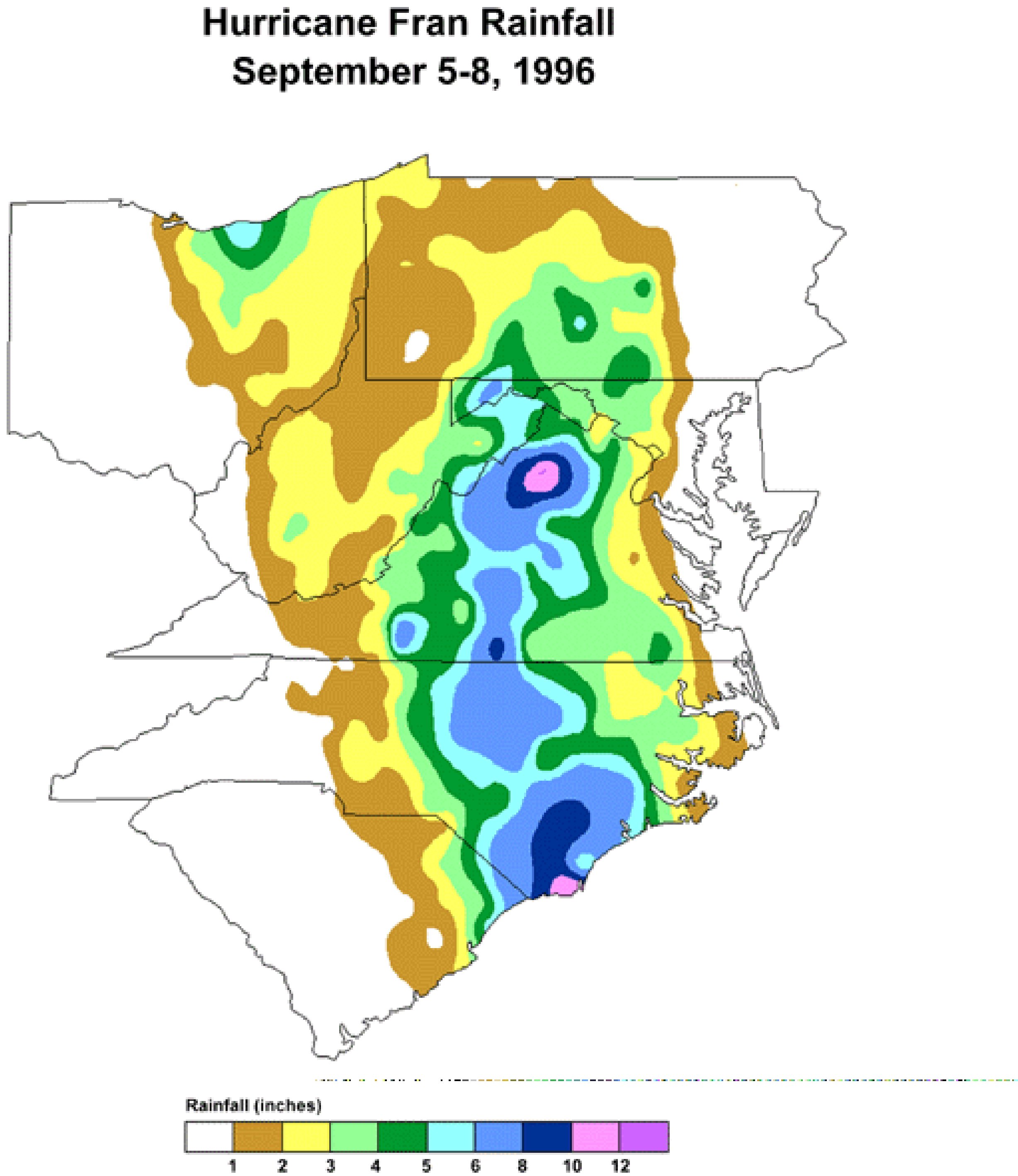

Hurricane Fran Rainfall
September 5-8, 1996
Rainfall (inches)
1
2
3
4
5
6
8
10
12

Figure 17

Table 3

Fran Rainfall(5 in. or greater), September 5-8,1996

St	Station	Lat. dg	Lat. mn	Lon. dg	Lon. mn	Total (in.)
VA	Luray 5 E	38	40	78	23	14.17
NC	Southport	34	0	78	1	12.65
NC	Willard 1 N	34	39	78	2	9.75
VA	Philpott Dam 2	36	47	80	2	9.50
VA	South Boston	36	42	78	53	9.29
VA	Appomattox	37	22	78	50	9.13
NC	Raleigh-Durham Arpt.	35	52	78	47	8.80
NC	Raleigh 3 W	35	44	78	41	8.59
NC	Durham	36	2	78	58	7.84
VA	Staunton Sewage Plant	38	9	79	2	7.78
NC	Chapel Hill 2 W	35	55	79	6	7.70
NC	Zebulon 2 WSW	35	48	78	22	7.65
NC	Elizabethtown Lock 2	34	38	78	35	7.61
NC	Clinton 2 NE	35	1	78	17	7.56
NC	Longwood	34	1	78	33	7.54
VA	Concord 4 SSW	37	18	78	59	7.54
VA	Front Royal 1 SSE	38	55	78	11	7.49
NC	Roxboro 7 ESE	36	19	78	54	7.44
NC	Whiteville 7 NW	34	24	78	48	7.32
NC	Rougemont	36	13	78	55	7.06
VA	Dale Enterprise	38	27	78	56	7.05
NC	Whiteville 5 S	34	16	78	42	7.01
NC	Butner Filter Plant	36	8	78	47	7.00
NC	Trenton	35	4	77	21	7.00
NC	Graham 2 ENE	36	5	79	22	6.98
VA	Free Union	38	5	78	34	6.98
NC	Neuse 2 NE	35	55	78	34	6.79
MD	Savage River Dam	39	31	79	8	6.75
SC	Loris 1 S	34	3	78	53	6.67
VA	Bremo Bluff	37	42	78	18	6.67
NC	Dunn 4 NW	35	19	78	41	6.56
VA	Charlottesville 2 W	38	2	78	31	6.50
MD	Frostburg 2	39	40	78	56	6.48
NC	Goldsboro 1 SSW	35	20	77	58	6.47
NC	Oxford Ag	36	17	78	37	6.47
OH	Elyria 3 E	41	23	82	3	6.47
VA	Lynchburg Municipal Arpt.	37	20	79	12	6.41
NC	Rocky Mount 6 SW	35	54	77	53	6.30
NC	Apex	35	45	78	50	6.29
VA	Palmyra 1 E	37	52	78	15	6.28
WV	Mathias	38	52	78	52	6.17
NC	Siler City 2 S	35	42	79	29	6.16
NC	Louisburg	36	6	78	19	6.09
WV	Romney 1 SW	39	20	78	46	6.09
NC	Sanford 8 NE	35	32	79	3	6.05
		Lat.		Lon.		Total

St	Station	dg	mn	dg	mn	(in.)
VA	Piedmont Research Stn.	38	13	78	7	6.04
NC	Wilmington 7 N	34	19	77	55	5.80
VA	Craigsville 2 S	38	3	79	23	5.80
NC	Lumberton	34	37	78	59	5.79
NC	Burlington Fire Stn	36	5	79	26	5.75
NC	Hofmann Forest	34	50	77	18	5.74
VA	Amelia Court House	37	18	78	2	5.74
VA	Woodstock	38	54	78	28	5.73
PA	Mapleton Depot	40	24	77	56	5.70
VA	Tye River 1 SE	37	38	78	56	5.67
VA	Warrenton 5 NE	38	41	77	46	5.66
NC	Fayetteville-Pope AFB	35	10	79	1	5.65
WV	Franklin 2 NE	38	40	79	19	5.58
VA	Sterling RCS	38	59	77	28	5.57
VA	Monticello	38	1	78	27	5.55
NC	Fort Bragg Water Plant	35	11	79	2	5.51
VA	Rocky Mount	37	0	79	54	5.50
VA	Mountain Grove	38	6	79	53	5.44
VA	Powhatan	37	33	77	56	5.43
WV	Wardensville RM Farm	39	6	78	35	5.43
OH	Cleveland Hopkins Ap	41	25	81	52	5.41
VA	Buchanan	37	32	79	41	5.40
VA	Copper Hill 1 NNE	37	6	80	8	5.39
VA	Charlotte Court House	37	4	78	42	5.37
NC	High Point	35	58	79	59	5.35
SC	Brookgreen Gardens	33	31	79	5	5.34
VA	Keysville 2 S	37	1	78	28	5.32
VA	Glasgow 1 SE	37	37	79	26	5.26
NC	William O. Huske L&D	34	50	78	48	5.25
PA	Beavertown 1 NE	40	46	77	9	5.22
WV	Keyser 3 E	39	25	78	57	5.21
NC	Reidsville 2 NW	36	23	79	42	5.20
NC	Henderson 2 SW	36	22	78	25	5.19
NC	Raleigh-City	35	47	78	42	5.16
PA	Glencoe 1 E	39	49	78	50	5.14
PA	Pine Grove Furnace	40	2	77	18	5.14
WV	Cacapon State Park 2	39	30	78	18	5.13
PA	Buckstown 1 SE	40	4	78	50	5.10

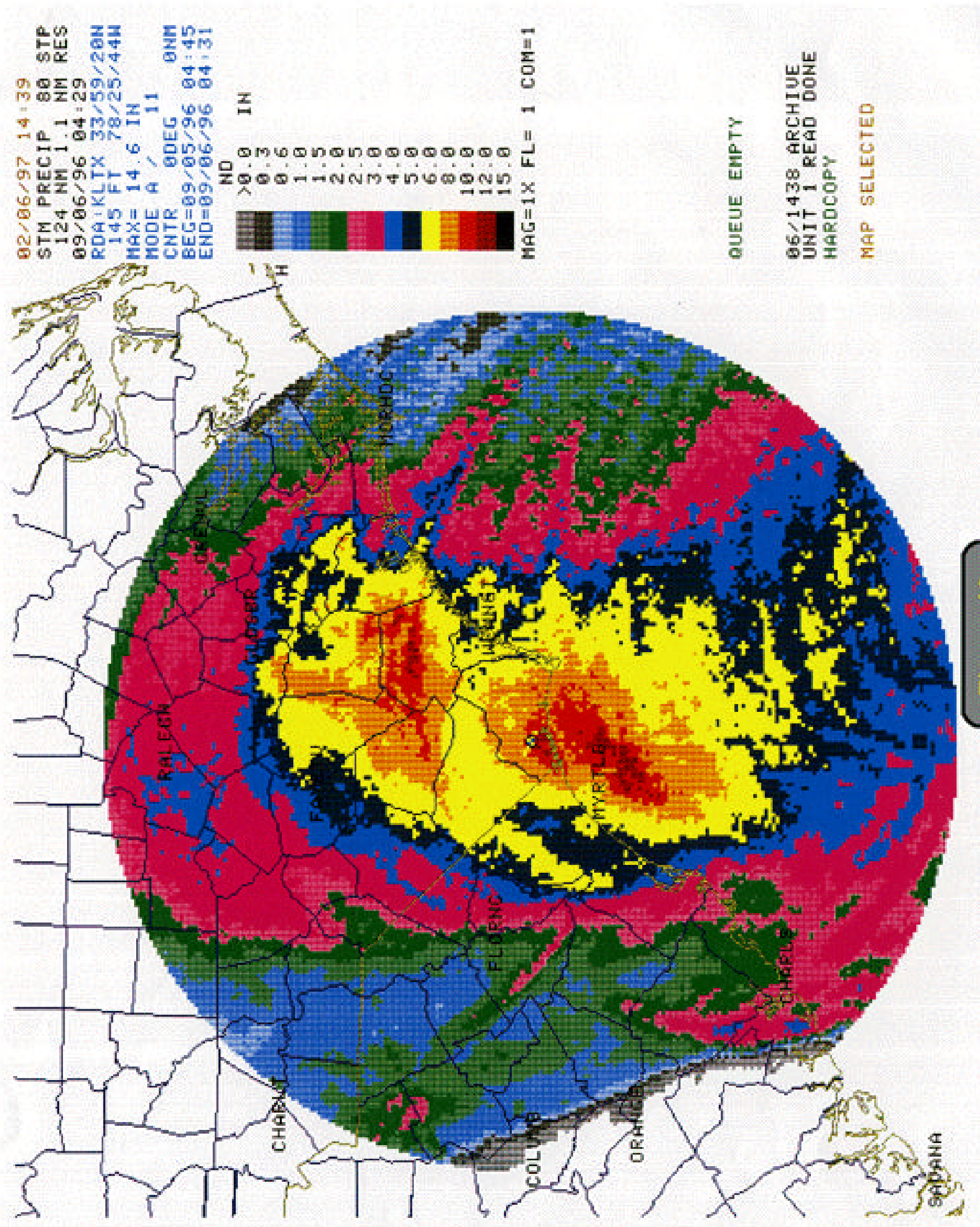

02/06/97 14:39
STM PRECIP 80 STP
124 NM 1.1 NM RES
09/06/96 04:29
RDA:KLTX 33/59/20N
145 FT 78/25/44W
MAX= 14.6 IN
MODE A / 11
CNTR 0DEG 0NM
BEG=09/05/96 04:45
END=09/06/96 04:31
ND
>0.0 IN
0.3
0.6
1.0
1.5
2.0
2.5
3.0
4.0
5.0
6.0
8.0
10.0
12.0
15.0
MAG=1X FL= 1 COM=1
QUEUE EMPTY
06/1438 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
MAP SELECTED
RALEIGH

Figure 18

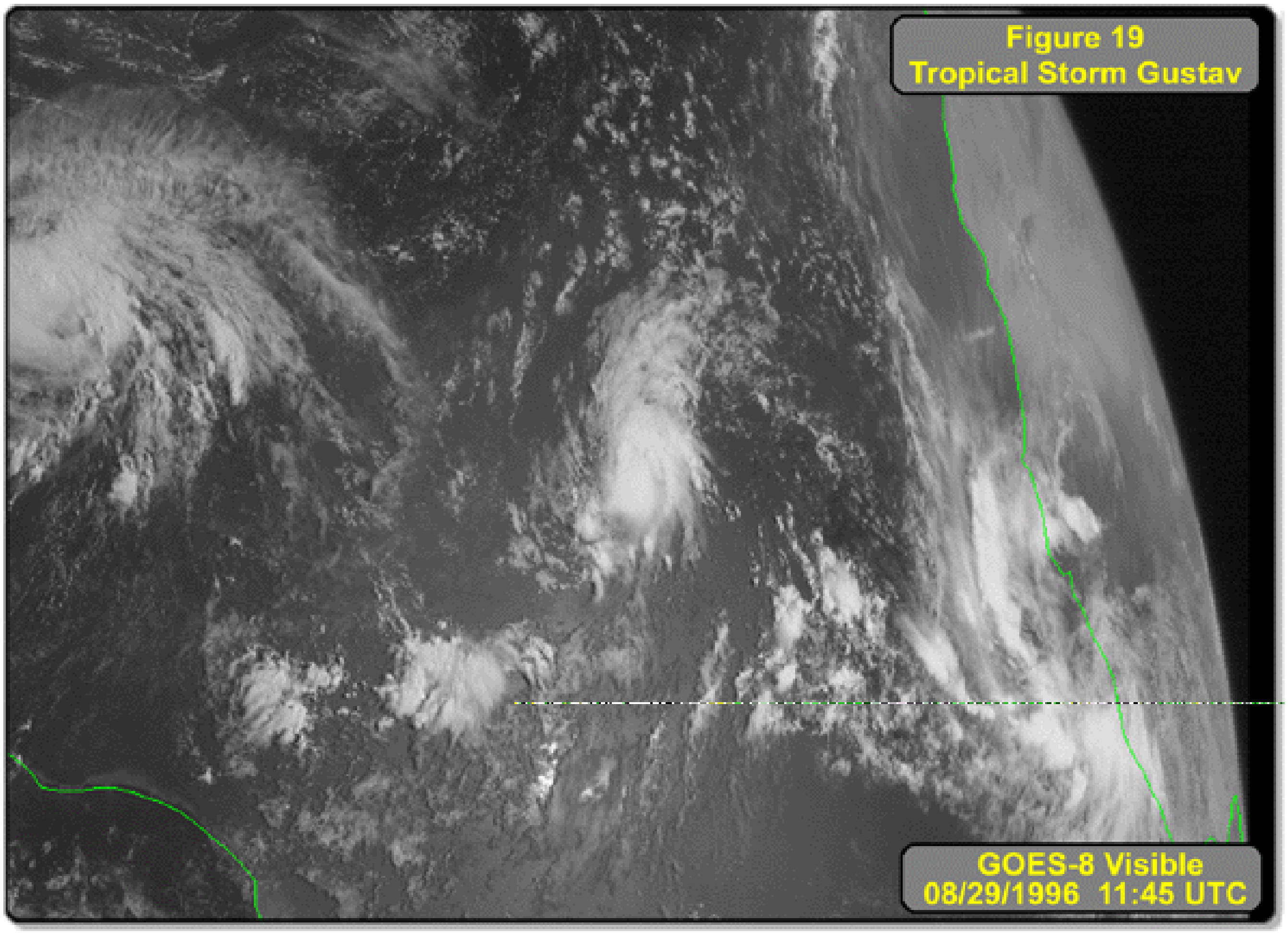


Figure 19
Tropical Storm Gustav
GOES-8 Visible
08/29/1996 11:45 UTC

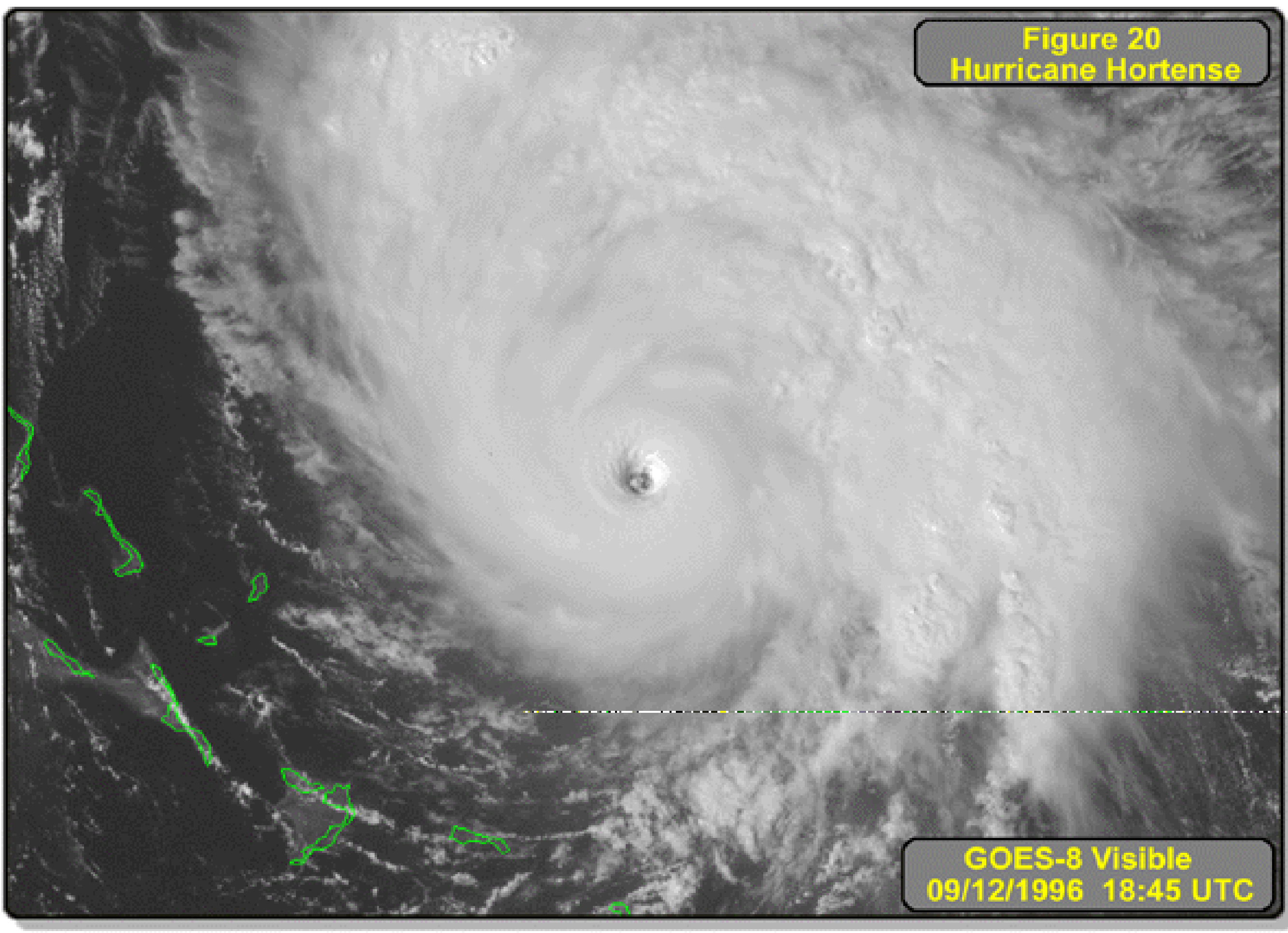


Figure 20
Hurricane Hortense
GOES-8 Visible
09/12/1996 18:45 UTC

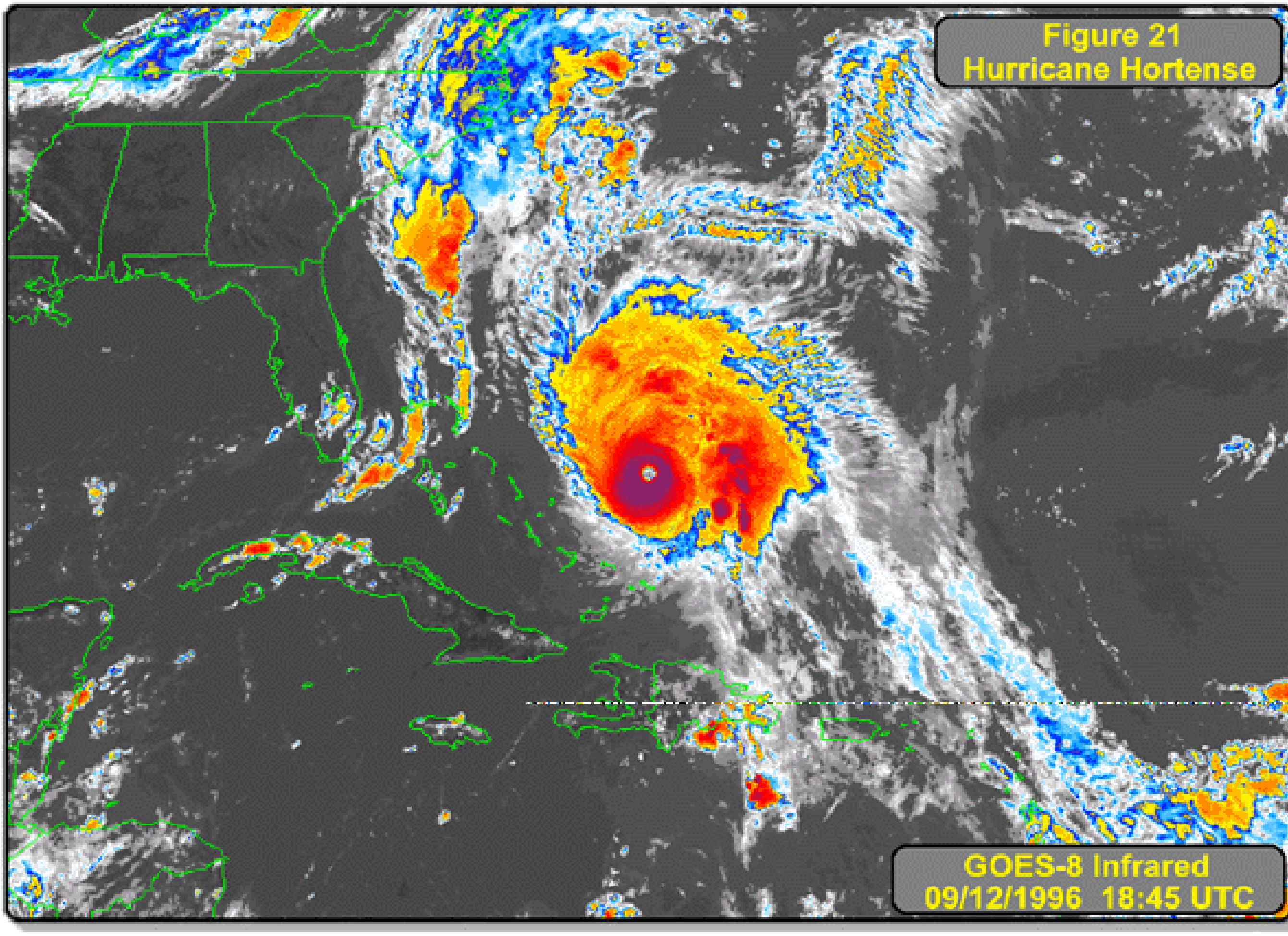


Figure 21
Hurricane Hortense
GOES-8 Infrared
09/12/1996 18:45 UTC

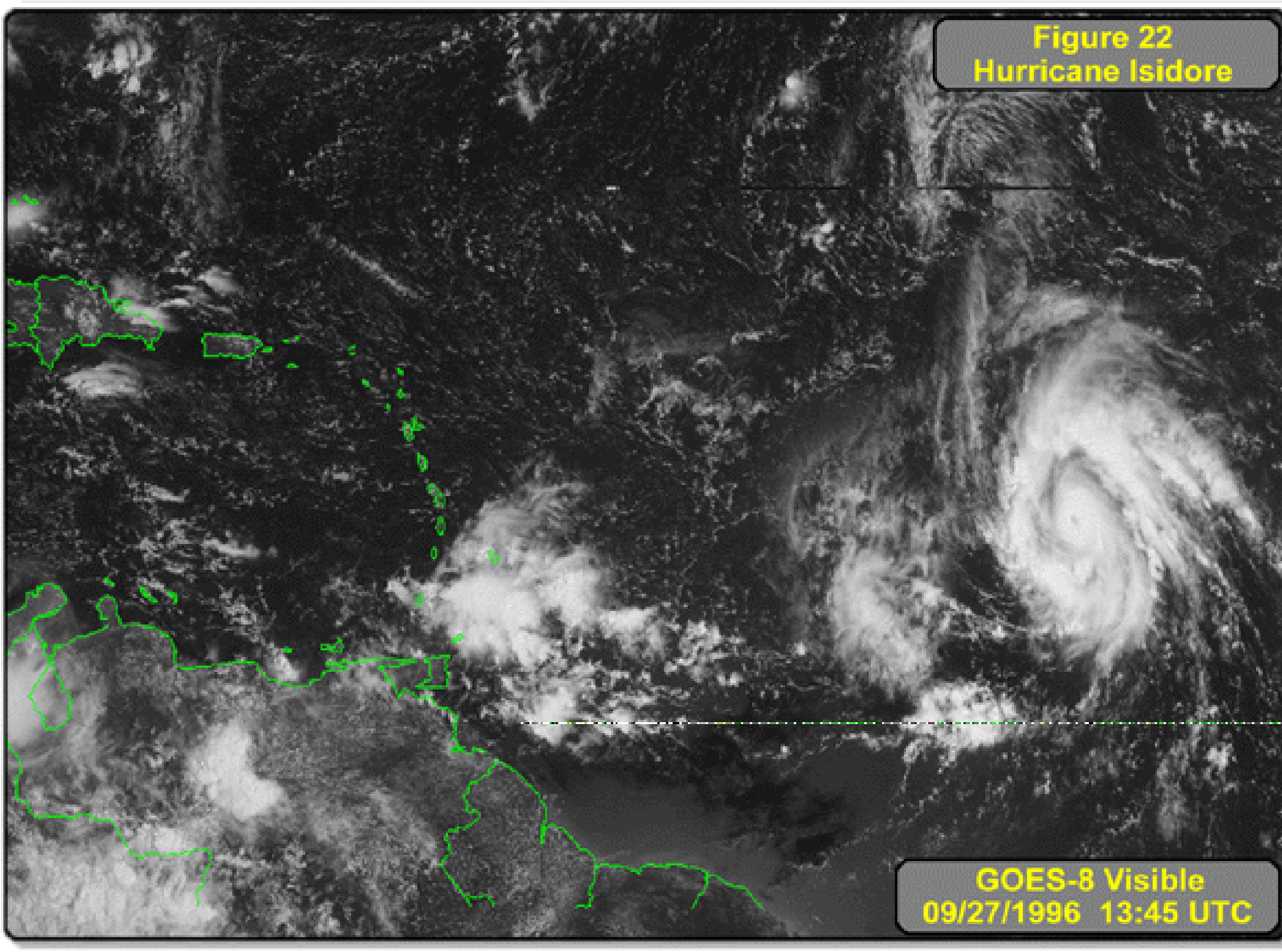


Figure 22
Hurricane Isidore
GOES-8 Visible
09/27/1996 13:45 UTC

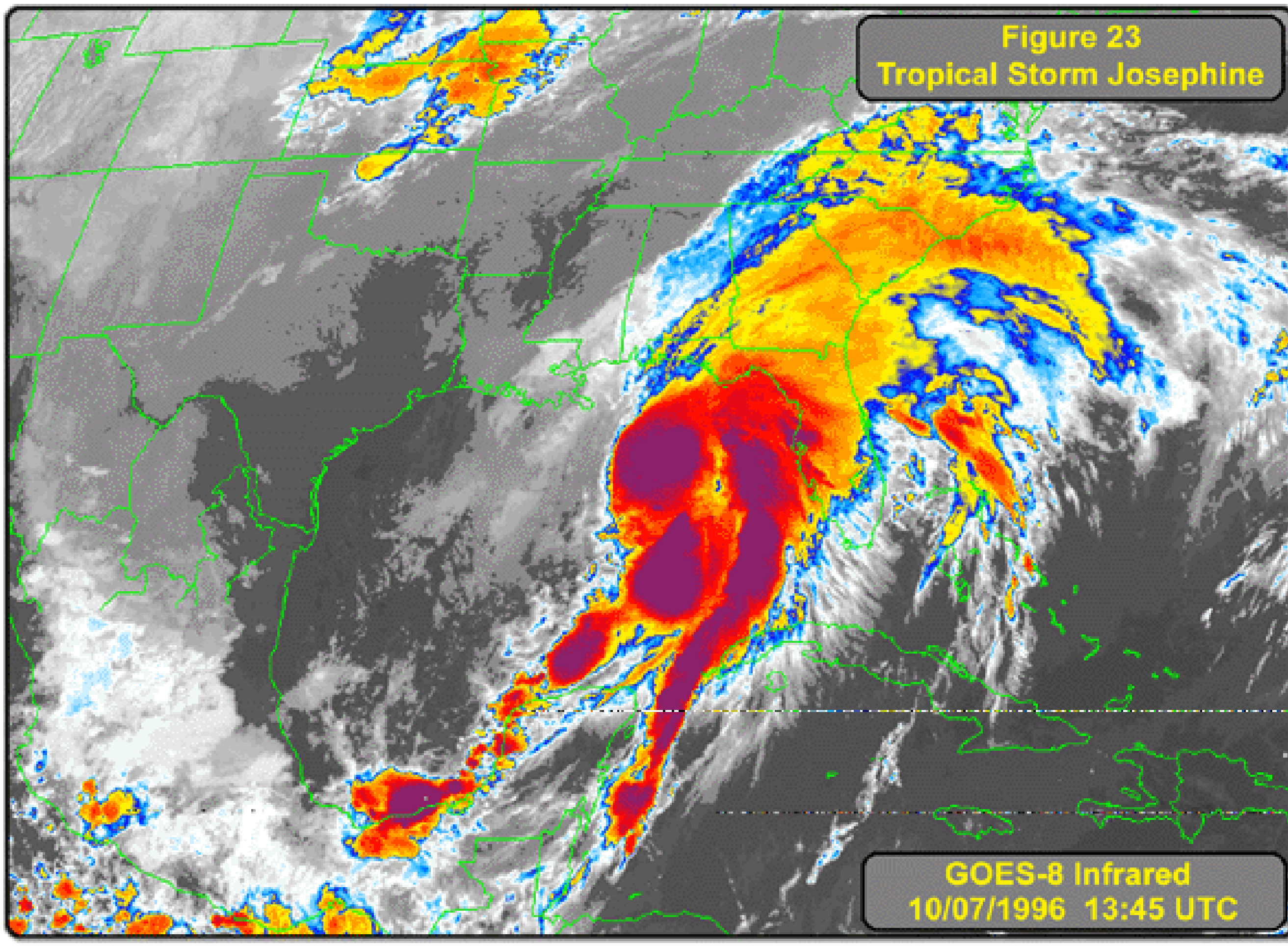


Figure 23
Tropical Storm Josephine
GOES-8 Infrared
10/07/1996 13:45 UTC

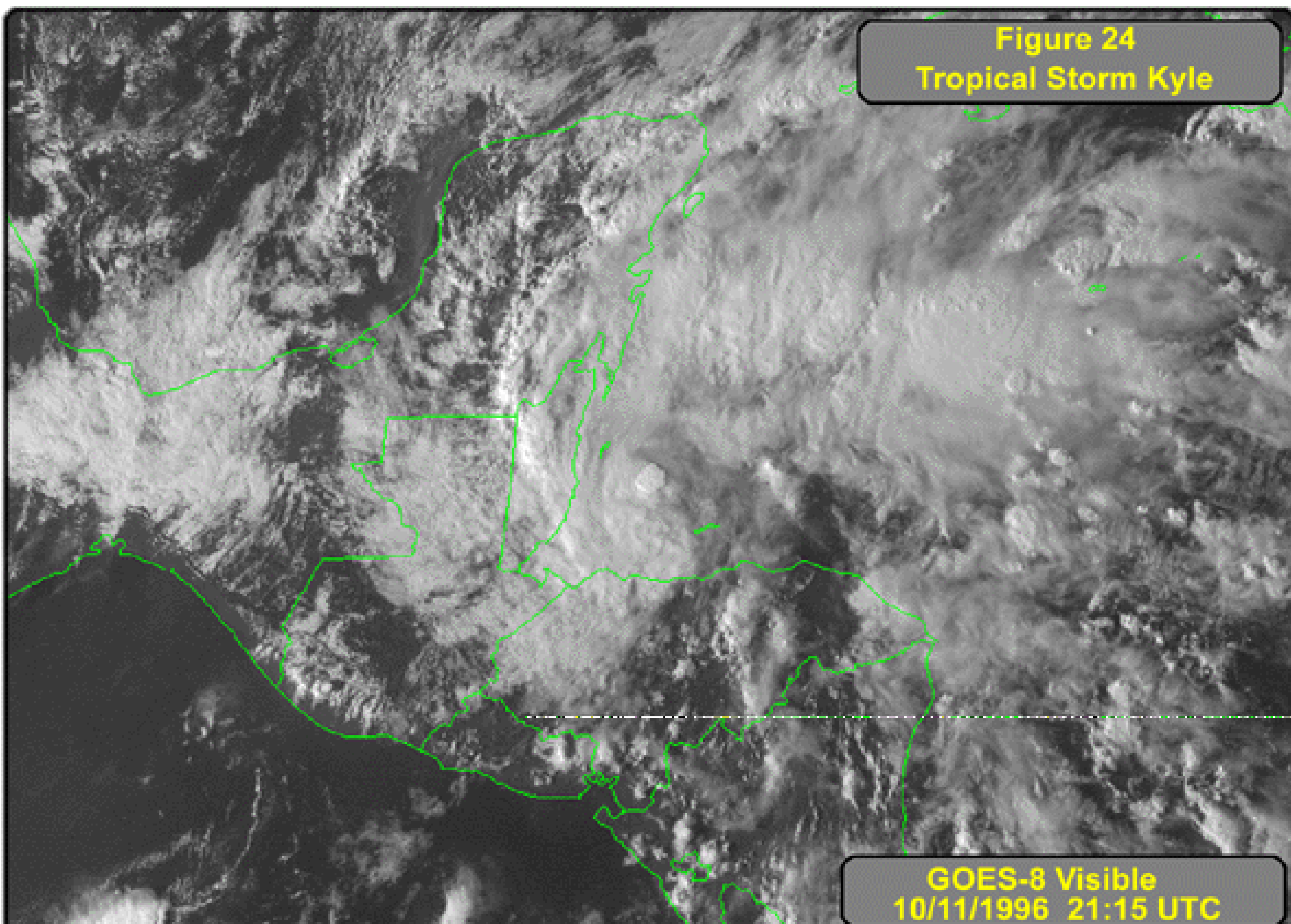


Figure 24
Tropical Storm Kyle
GOES-8 Visible
10/11/1996 21:15 UTC

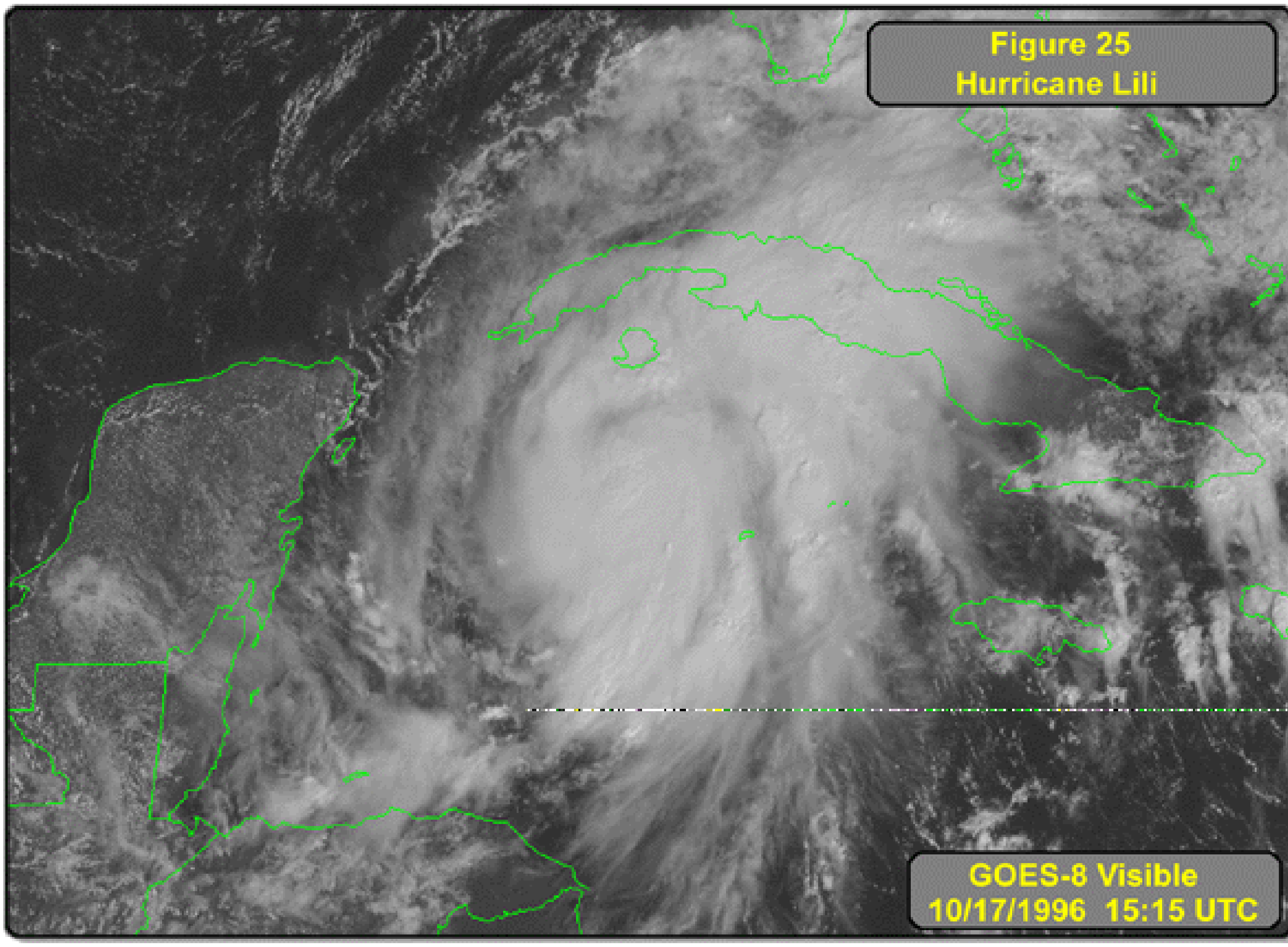


Figure 25
Hurricane Lili
GOES-8 Visible
10/17/1996 15:15 UTC

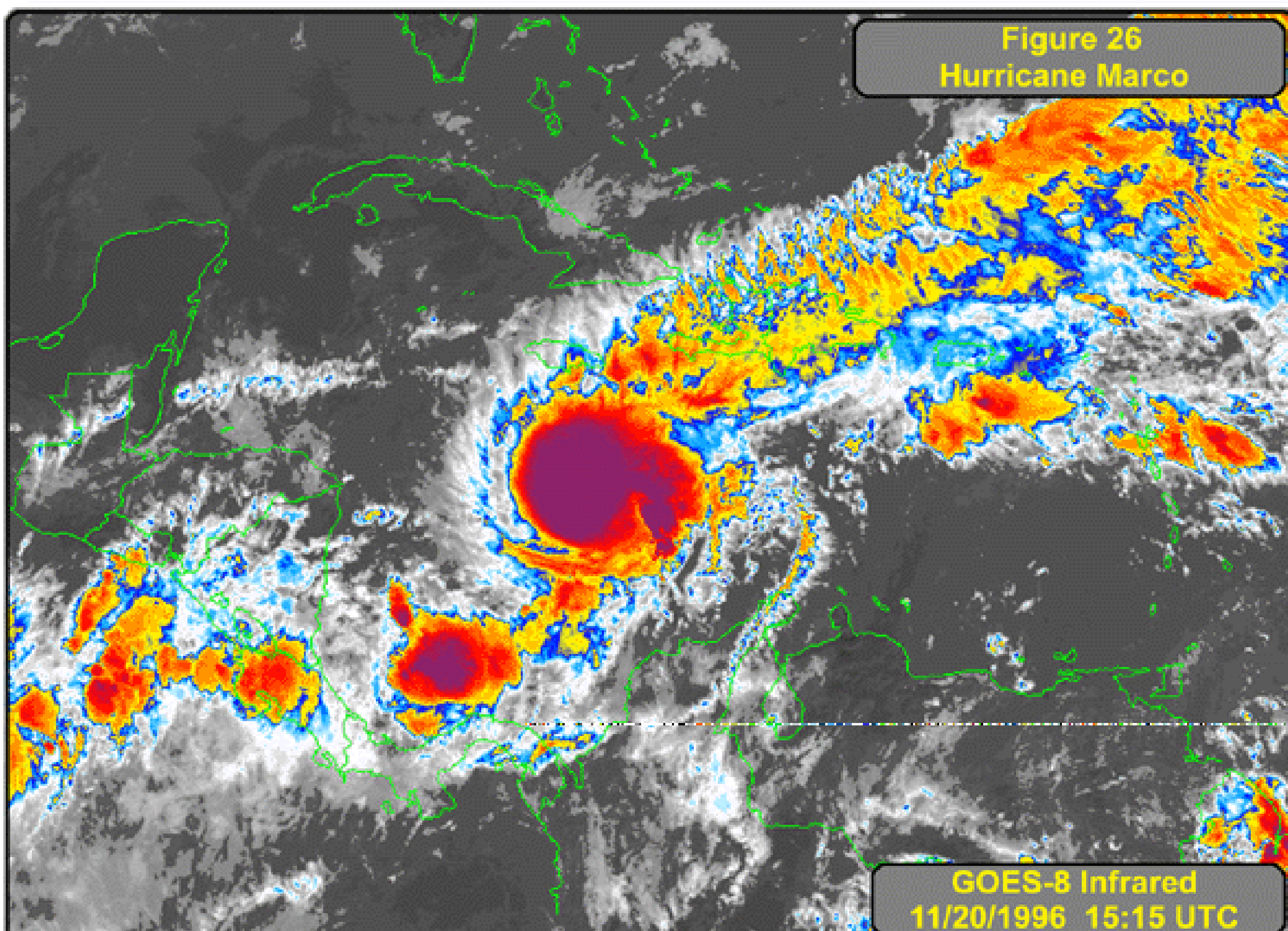


Figure 26
Hurricane Marco
GOES-8 Infrared
11/20/1996 15:15 UTC

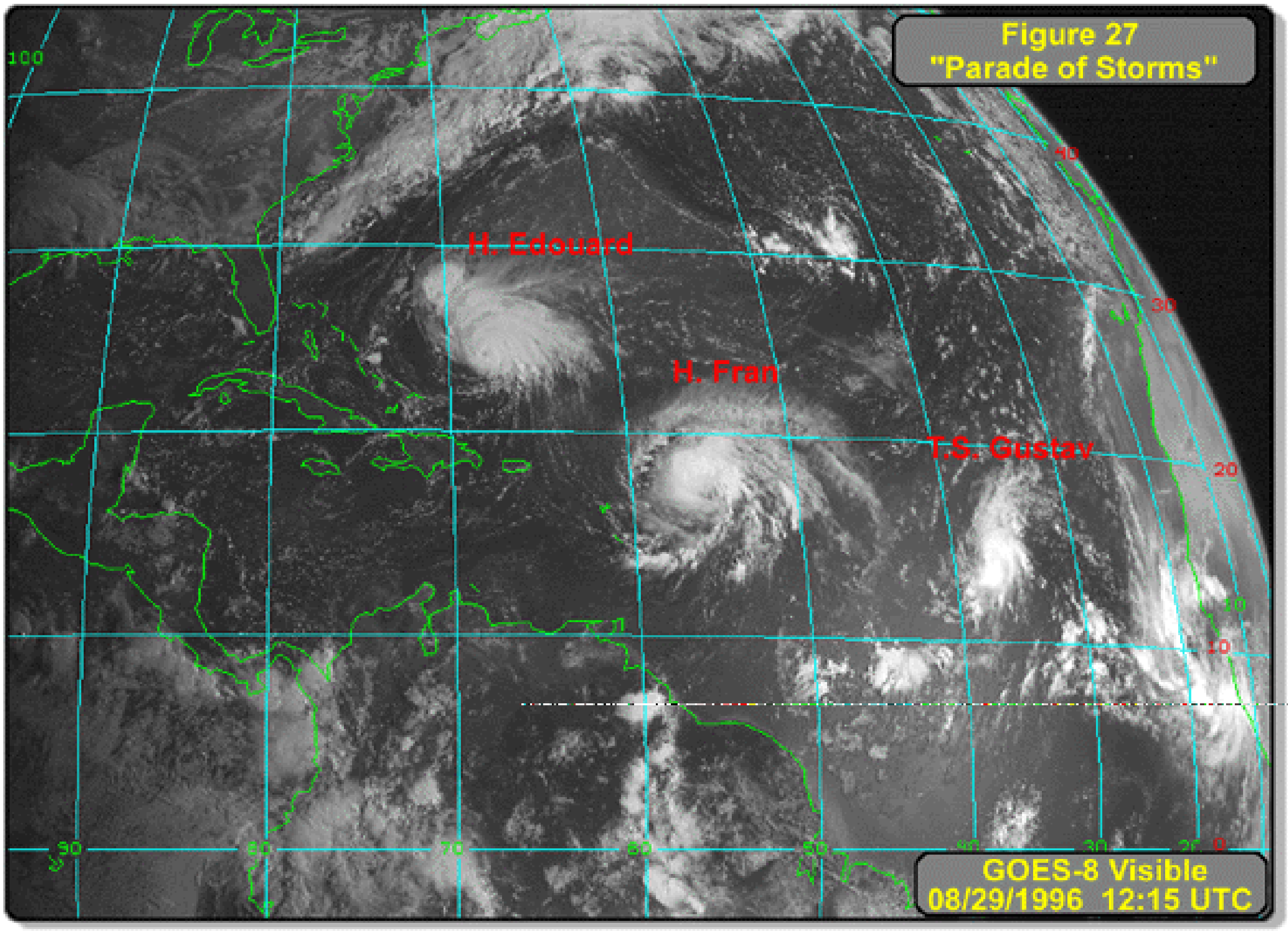


Figure 27
"Parade of Storms"
H. Edouard
H. Fran
T.S. Gustav
GOES-8 Visible
08/29/1996 12:15 UTC

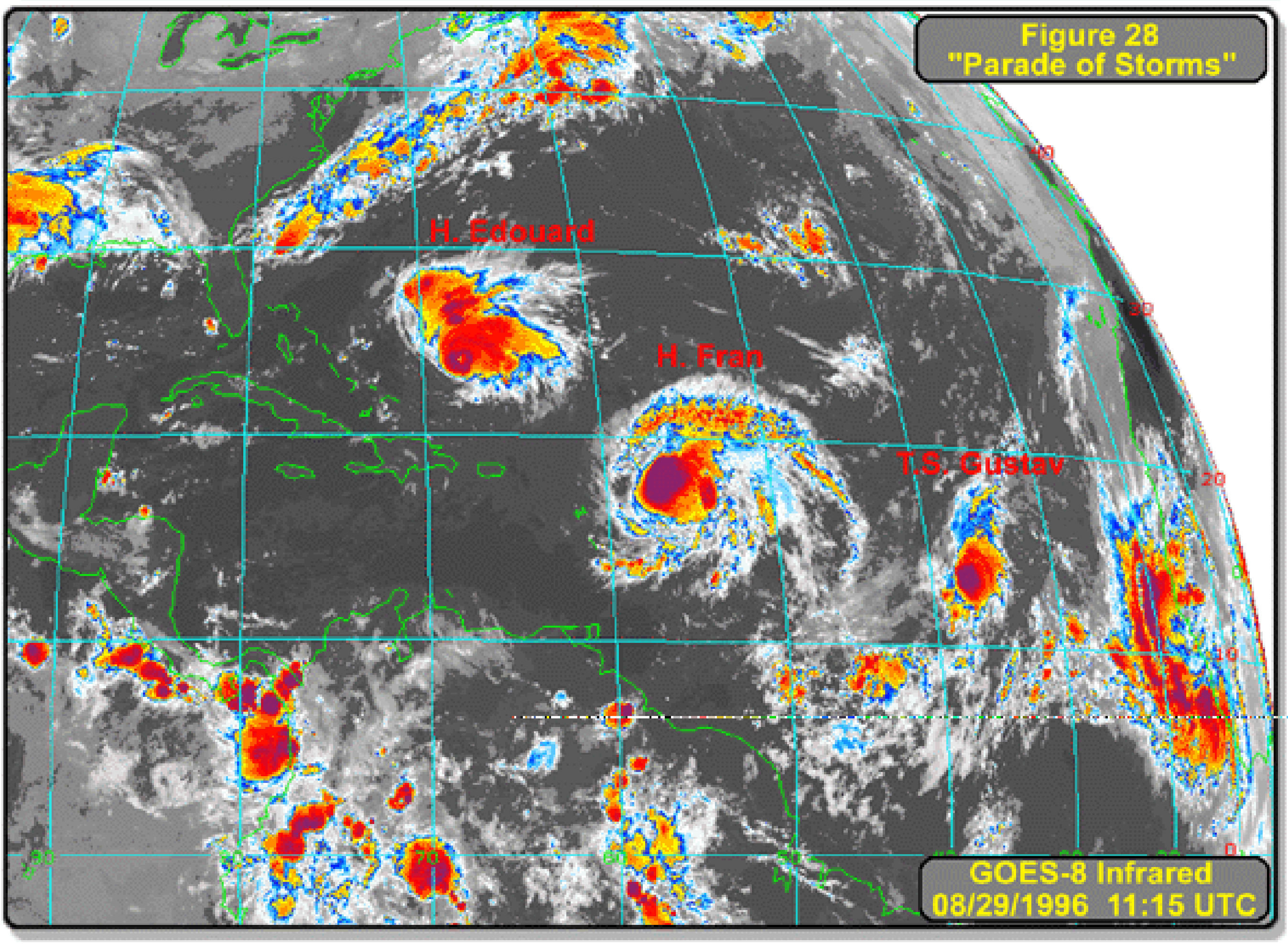
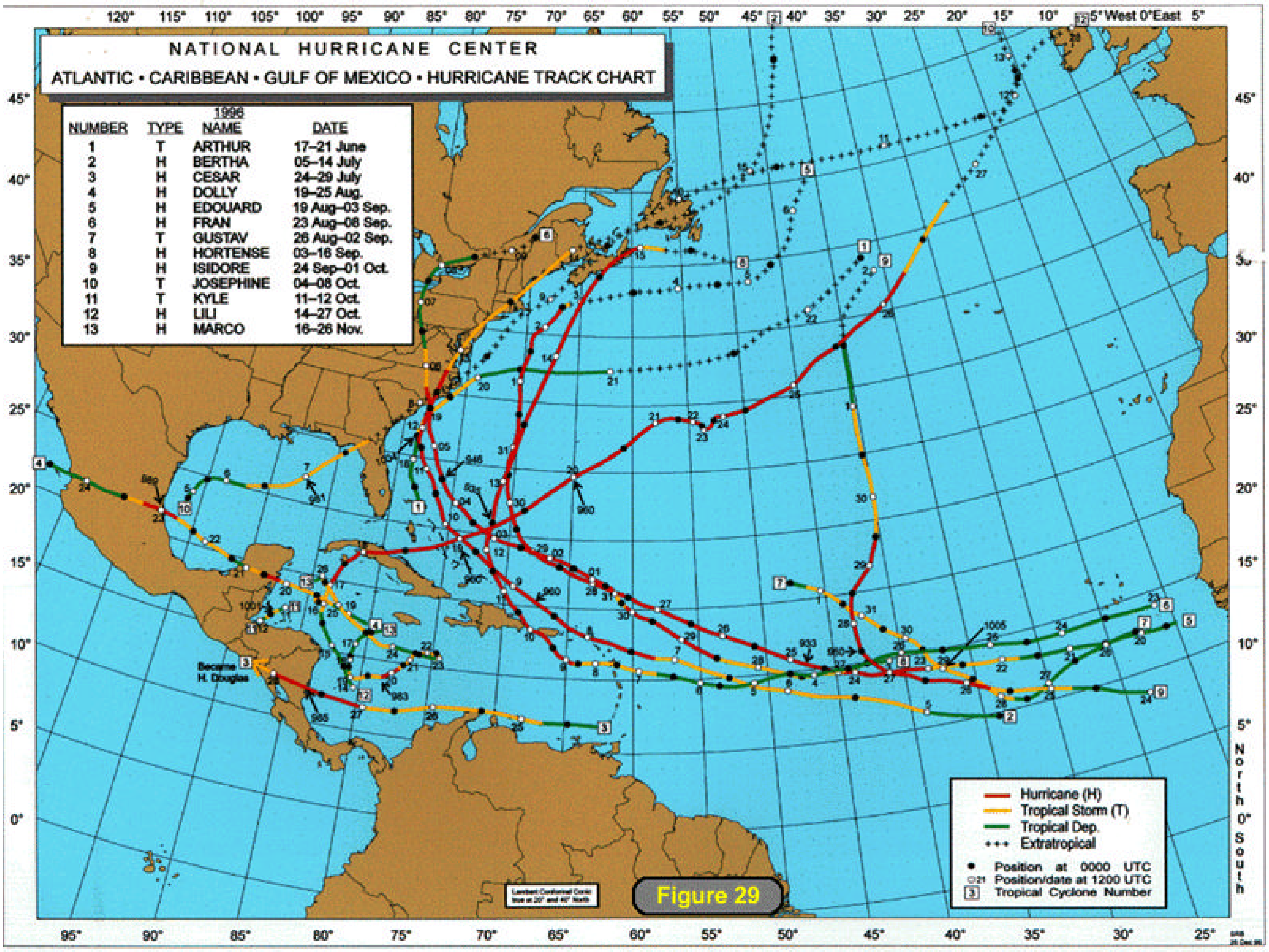


Figure 28
"Parade of Storms"
H. Edouard
H. Fran
T.S. Gustav
GOES-8 Infrared
08/29/1996 11:15 UTC


NATIONAL HURRICANE CENTER
ATLANTIC • CARIBBEAN • GULF OF MEXICO • HURRICANE TRACK CHART
1996
NUMBER TYPE NAME DATE
1 T ARTHUR 17–21 June
2 H BERTHA 05–14 July
3 H CESAR 24–29 July
4 H DOLLY 19–25 Aug.
5 H EDOUARD 19 Aug–03 Sep.
6 H FRAN 23 Aug–08 Sep.
7 T GUSTAV 26 Aug–02 Sep.
8 H HORTENSE 03–16 Sep.
9 H ISIDORE 24 Sep–01 Oct.
10 T JOSEPHINE 04–08 Oct.
11 T KYLE 11–12 Oct.
12 H LILI 14–27 Oct.
13 H MARCO 16–26 Nov.
Became H. Douglas
Hurricane (H)
Tropical Storm (T)
Tropical Dep.
Extratropical
Position at 0000 UTC
Position/date at 1200 UTC
Tropical Cyclone Number
West
East
North
South
Figure 29